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ABSTRACT

This report is the product of an effort by the Office of Technology Policy to assess current and future needs for information technology (IT) workers through a comprehensive information-gathering project that included the following three activities: (1) nationwide regional meetings that included discussions with industry executives, representatives from academia, business leaders, students, and workers; (2) examination of a wide range of data on the IT workforce; and (3) regular monitoring of literature on the subject. The following are among the topics discussed in Chapters 1-9: (1) the challenge of developing the IT workforce; (2) the vital role of IT in the U.S. economy; (3) the business environment and its impact on the IT labor market; (4) the demand for core IT workers; (5) the supply of core IT workers; (6) indications of a tighter labor market; (7) state and regional perspectives; (8) a report of the National Dialogue on the Information Technology Work Force; and (9) answers the IT workforce challenge. Chapters 1-9 contain 45 tables/figures. Chapter 10 consists of four appendixes on the following four topics: (1) employment sectors for core IT workers; (2) core IT workforce distribution by industry; (3) core IT

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workforce distribution by occupation; and (4) state employment projections in core IT occupations for 1996-2006. (MN)

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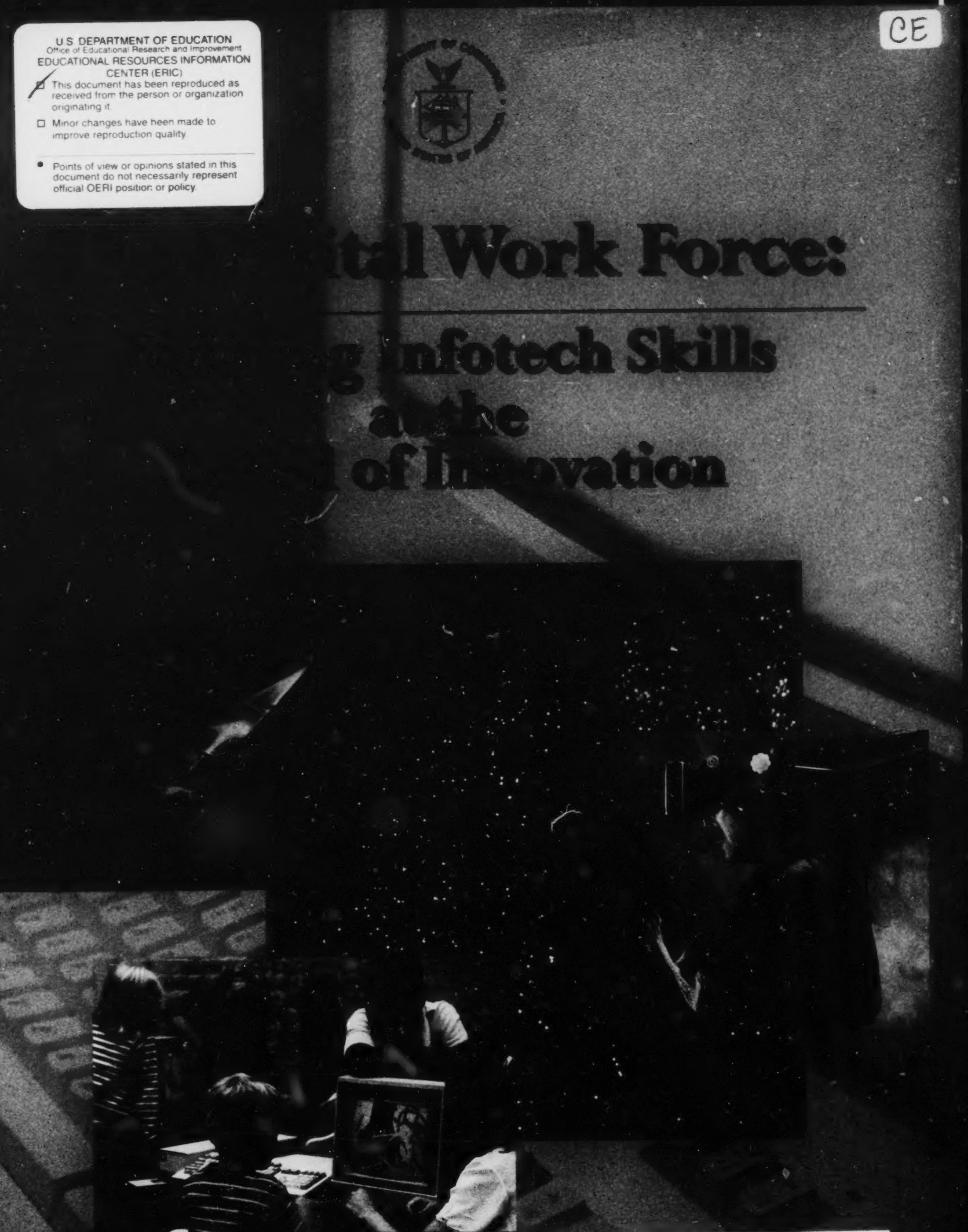

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THE DIGITAL WORK FORCE:
Building Infotech Skills at the Speed of Innovation

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FOREWORD

In January of 1998, the U.S. Department of Commerce sponsored—with private sector organizations and other Federal agencies—the Information Technology Work Force Convocation in Berkeley, California. At the convocation, representatives of government, industry, academia, and employees began a dialogue exploring the challenge of developing America's human capital for the Information Age. Secretary of Commerce William Daley pledged to continue the dialogue by convening town meetings around the country to bring together state and local governments, local business leaders, and other stakeholders to discuss their regional information technology work force needs and how to meet them.

The dialogue included regional meetings sponsored by the Department of Commerce, as well as other meetings around the country in which Department of Commerce officials participated. These spanned the country, and included meetings in diverse economic regions, including high technology-based regions (San Francisco, Austin, Seattle, and Boston), centers of traditional manufacturing (Chicago), regions that have emerging technology and service industries (Mississippi, North Dakota, and Phoenix), and areas that have been hit by recent corporate downsizing (Hudson Valley, New York). Each meeting included discussions with industry executives, representatives from academia, companies, students, and workers.

National Dialogue on Information Technology Work Force

Berkeley, California	National Information Technology Work Force Convocation, January 12-13, 1998
Austin, Texas	Women in Technology International (WITI) Conference on Business of Technology, March 26, 1998
Montgomery County, Md.	Town Forum on Developing a Competitive Information Technology Work Force, May 11, 1998
Brooklyn, New York	11th Congressional District Synergy Town Meeting and Planning Conference, June 13, 1998
Jones County, Mississippi	Gulf States Regional Forum on Developing a Competitive Information Technology Work Force, June 24, 1998 (the states of Mississippi, Alabama, and Lousianna participated)
New Paltz, New York	Hudson Valley Information Technology Work Force Challenge, June 30, 1998
Bellevue, Washington	Pacific Northwest Regional Forum on Developing a Competitive Information Technology Work Force, August 18, 1998
Chicago, Illinois	Chicago National Coalition for Advanced Manufacturing, September 9, 1998
Omaha, Nebraska	Town Meeting on the Information Technology Crisis, September 11, 1998
Chicago, Illinois	IT Work Force Solutions Conference, Chicago Software Association, October 13, 1998
Boston, Massachusetts	Women in Technology International (WITI), October 19, 1998
Bismark, North Dakota	The Information Technology Worker Shortage: An Opportunity for North Dakota, October 28, 1998
Phoenix, Arizona	Arizona Town Forum on Developing a Competitive Information Technology Work Force, December 16, 1998

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In addition to these meetings, Commerce Department staff participated as panelists at numerous other meetings and conferences, and served on a high-level task force for the Federal CIO Council exploring IT work force issues related to the Federal work force. Staff also examined a wide range of data on the IT work force, and regularly monitored new literature on the subject, including academic reports, reports in the media, commentary, and expert testimony before the U.S. Congress.

The meetings, reports, data, and other literature provided a rich picture of IT work force issues around the country, and highlighted some of the steps being taken by communities, companies, and schools to address the challenge of strengthening America's IT work force.

This report summarizes the findings from this process. It describes the importance and complexity of IT work force issues, describes what we learned from the dialogue, shares innovative practices from around the country, and lays out some options for government, industry, educators, and workers.

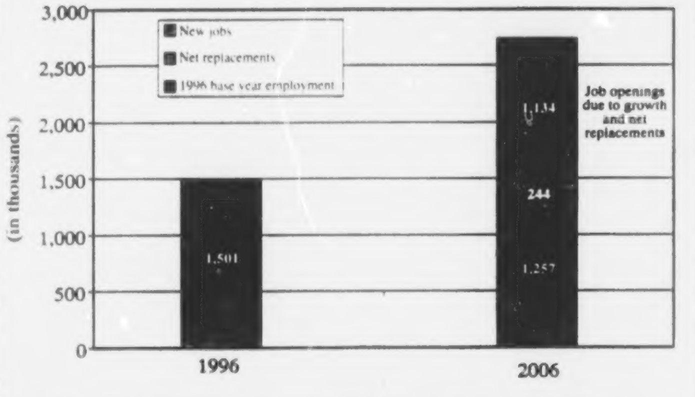
EXECUTIVE SUMMARY

The digital work force challenge has been the subject of much debate among representatives of industry (who believe there is a shortage of information technology (IT) workers), employee groups (who believe adequate numbers of highly trained technical professionals are available) and economists (who argue that market forces will take care of any problem). Each of these perspectives has merit, but the true nature of the challenge is more complex than any of these views individually. The challenge is driven by the unique nature of information technology and its pervasive role throughout the U.S. economy and our society.

This report discusses the impact of rapid creation and adoption of IT on the U.S. economy, describes the demand and supply trends for core IT occupations, discusses the business environment and its impact on the IT labor market, and proposes steps key stakeholders can take to address the challenge. Key findings and conclusions are:

- **Demand for core IT workers is strong and growing.** For more than 15 years, employment in the core IT occupations—computer scientists and engineers, systems analysts, and computer programmers—has grown six times faster than the overall U.S. job growth rate. The growth for computer scientists and systems analysts has accelerated in recent years, increasing at an annual rate of 16.4 percent.
- **From 1996 to 2006, it is projected that the United States will require more than 1.3 million new highly-skilled IT workers in these occupations.** About 1,134,000 workers will be needed to fill newly created jobs and approximately 240,000 will be needed to replace workers who are leaving these fields.
- **The impact of the digital work force challenge varies from industry to industry.** The computer and data processing services industry—which consists of many companies that focus on the development of software and services, or IT projects under contract for other firms—has much at stake because it employs the greatest number of core IT workers. In 1996, the CDPS industry employed 26.9 percent of all core IT workers. By 2006, the CDPS industry is projected to employ nearly two out of every five core IT workers (39.3 percent).
- **By 2006, California, Texas and Virginia are projected to have the largest core IT work forces.** These states also lead the country in the average number of core IT job openings between 1996 and 2006.
- **Oregon, Georgia and Colorado top the list of states with the fastest growing cadre of core IT workers between 1996 and 2006.** Oregon is projected to triple its core IT work force, while the core IT work force in Colorado and Georgia is projected to double in size.
- There is evidence pointing to a tight labor market for highly-skilled IT workers—such as rapid growth in highly-skilled IT occupations, low unemployment rates and rising salaries, with some worker salaries reportedly rising significantly. **However, due to the limitations of available data, there is no way to establish conclusively whether there is, or is not, an overall IT worker shortage.**

High Demand Projected for Information Technology Workers



Source: U.S. Department of Commerce analysis of U.S. Department of Labor, Bureau of Labor Statistics Data

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- **IT labor markets are complex and dynamic.** Supply and demand characteristics vary by industry segment, by IT occupation, and by specific skills. Short product life cycles, and the variety of software and hardware products and their applications, together with the differing business requirements of different industry sectors, have created demand for workers with various combinations of IT skills, experience, and industry knowledge—expressed often by employers as needing "the right person with the right skills at the right time." Time-sensitive competitive pressures and the need for employees with various combinations of technical skills, business skills, and hands-on experience have led many employers, especially those for whom IT is their core business, to pursue "buy" decisions in this labor market rather than "make" decisions (to hire, then train for the task).

- **There is no single path to prepare a worker for a core IT job.** Most get their education from four-year colleges. Other paths include two-year degree-granting community colleges, special university/community college one-year programs designed to upgrade the skills of current IT workers, private sector certification programs, in-house company training, computer user groups, Internet forums, and company-sponsored help sites. Two-thirds of all workers in core IT occupations hold a bachelor's degree or higher, 26 percent have less than a four-year degree, and six percent have a high school diploma or less. Of those with degrees, 46 percent have IT degrees, minors or second majors; 86 percent have a degree in a science or engineering discipline.

- **Americans can meet the digital work force challenge. Markets are responding to the growing demand for IT workers in many ways.** For example:
  - After years of declining enrollments, four-year college enrollment rates are increasing in IT-related disciplines. In the past three years, bachelor-level enrollments in leading computer science and computer engineering programs more than doubled.
  - A significant and growing training infrastructure is emerging. Community colleges are responding to the need for increased IT training, and proprietary training and IT certification programs are growing in number and popularity. Many workers are now able to qualify for low to medium-skilled IT jobs through such programs.
  - Corporations are increasing on-the-job training and forming industry-education-community partnerships to expand IT education at all levels.
  - States and regional organizations have begun to develop a variety of strategies for attracting and developing people with IT skills.

- **Many factors affect the supply and quality of IT workers.** These include a poor image of the IT profession, lack of career information and encouragement for students, the need for increased competency in math and science, challenges in the IT teaching infrastructure, and failure to attract underrepresented groups to the profession.

Key Recommendations

The resounding conclusion from our nationwide dialogue is that there is no "silver bullet" solution to the IT work force challenge. Rather, the answer lies in many stakeholders undertaking a wide range of initiatives, both large and small. Most of the suggestions for key stakeholders presented in this report provide actions well within the reach of individual stakeholders in the business, government and education communities.

Businesses should:

- Support and develop national information and advertising campaigns to improve the image of the technical professions, and communicate the portfolio of skills needed to thrive in the new economy.
- Form consortia or collaborate in other ways to reduce the cost and risk of incumbent worker training. Businesses—acting alone or in partnership with education, government and other stakeholders—should assess IT training needs, develop curricula, train current or prospective employees, and develop ways to help employees get experience in applying the technical skills they acquire through training.
- Consider expanding resources for employees to participate in training programs. Businesses could provide scholarships, low interest loans, or time off work for employees participating in training.
- Companies that certify training providers—such as Microsoft, Novell, and Cisco—should work closely with national, regional, and specialized accrediting agencies to ensure accreditation of their training providers so that students can qualify for Federal financial aid.
- Tap into non-traditional labor pools, including older workers, mid-career scientists and engineers, recent college graduates trained in non-IT disciplines, and women and minorities.
- Partner with universities and community colleges to improve curricula quality, timeliness and value, and develop programs that meet employers' changing IT education and training needs.
- Where needed, consider funding and other support to relieve pressure on university and community colleges' IT teaching infrastructure. This includes strategies to recruit, retain and maintain skills' currency of faculty.
- Increase the quality of K-12 science and math teaching through mechanisms such as funding stipends, internships, or scholarships for teachers in math and science; helping defray the cost of qualified technology teachers; encouraging greater teacher involvement with industry; and increasing in-kind contributions of equipment and personnel to the educational system.
- Encourage technical workers to get involved in local school systems by providing time off during working hours (or other means) to teach, mentor, or work on science and engineering projects with students.
- Provide hands-on opportunities for students to gain real-world experience with high technology industry and technical careers.

Universities and Community Colleges should:

- Work together with industry and government to support and develop national information and advertising campaigns to improve the image of the technical professions, and communicate the portfolio of skills needed to thrive in the new economy.
- To encourage incumbent worker training, create greater flexibility in IT training, including offering shorter courses, increasing the variety of course times and locations, and expanding the use of teletraining.
- Examine the adequacy of the teaching infrastructure for four-year and two-year IT-related degree programs (seats, equipment and faculty).

- Retain qualified IT teachers through competitive pay and other benefits. Faculty who obtain IT certifications should be rewarded for their achievement as a way to retain them in teaching.
- Find much faster ways to upgrade curricula through regular surveys of skills needs, ongoing dialogue with IT business leaders and technical professionals, and more monitoring of the business environment and technological trends.
- Bring faculty to industry through summer internships and sabbaticals, rotation programs, and through exchange programs for industry and university scientists and engineers. Encourage faculty to establish relationships with counterparts in high technology industries.
- To improve the education of K-12 teachers, encourage collaborations between schools of education and college math, science and engineering departments. Create and implement IT curricula in schools of education.
- Develop partnerships between science and technology departments, and business schools to provide business majors and MBAs with technical skills, and offer people graduating in non-IT fields some courses in IT.
- Provide hands-on opportunities for students to gain real-world experience in high technology industry and technical careers. Bring professionals with real-world experience into the classroom at all levels.
- Aggressively recruit women and minority faculty for science and technology programs at the K-12 and college levels.

Governments should:

- Improve data collection on the supply of and demand for highly-skilled IT workers, and factors affecting the IT labor market.
- Work with individuals, businesses, associations, academia and the media to support and develop national information and advertising campaigns to improve the image of the technical professions, and communicate the portfolio of skills needed to thrive in the new economy.
- Promote government scientists and engineers as role models and publicize the exciting diversity and value of their work.
- State governments should consider expanding student opportunities by working with business and academia to fund scholarships for high school students, college students, or current workers who commit to working for a contributing company or within states or regions where the need for IT workers is growing.
- Consider incentives to increase the number of qualified science and technology teachers in the K-12 grades.
- Support, through special educational programs, mentoring, outreach and other means, greater participation of women, underrepresented minorities and disabled people in the IT work force.
- Consider incentives to reduce the cost and risk to industry of incumbent worker training in order to stimulate increased industry investment. For example, governments could provide matching funds to organize and encourage cooperation among firms in developing industry-led skills alliances, as well as participate in alliances as employers in areas where IT workers are needed to fill government jobs.
- Review government supported training programs and contract training providers to ensure they are aligned with employer needs, growing career areas, and job markets in which they operate.
- Work together with business and educators to provide K-12 students, especially middle school students, with information on science and technology careers, their rewards, and what education and training are necessary to pursue them.

I. OVERVIEW OF THE CHALLENGE

The nature of America's information technology (IT) work force challenge has been the subject of much debate over the past several years. There are many conflicting views of the challenge, and even among those who agree on the nature of the challenge, there are conflicting views of what the best solutions are. The perception of the challenge tends to be shaded by the perspective of the observer.

For the most part, industry sees the problem as a worker shortage. Companies believe that there simply aren't enough people in the IT occupations to meet the growing demand.

Employee groups and advocates for employees, on the other hand, believe there are enough trained technical professionals in the United States, but industry has not tapped these existing labor pools.

And economists argue that the IT work force challenge is the expected result of the rising importance of IT in our economy and the consequent demand for highly-skilled core IT workers, and that, in the long run, market forces will fix the problem.

> *However, it is our conclusion that the true nature of the challenge is more complex than any of these views individually, and that the challenge is driven by the unique nature of IT and its pervasiveness throughout the U.S. economy and our society.*

The Office of Technology Policy finds merit in each of the perspectives. However, it is our conclusion that the true nature of the challenge is more complex than any of these views individually, and that the challenge is driven by the unique nature of IT and its pervasiveness throughout the U.S. economy and our society. Two factors are chiefly responsible for creating the IT worker challenge.

First, there has been sustained rapid growth in the demand for highly-skilled IT workers—demand that has accelerated in recent years. This demand is the product of the Information Age—virtually every segment of the American economy has embraced IT for the productivity improvements it brings to existing business functions, as well as for the new capabilities, products and services IT enables. The ubiquity of IT can be seen almost everywhere: in the shift of business's equipment investment into information technologies, in the unprecedented emergence of the web as a venue for commerce and communication, and in the proliferation of computers in businesses and homes to name a few. As a result, demand for highly-skilled IT workers leads all other occupations and is expected to continue in the years ahead.

Second, the variety and complexity of software and hardware products and their applications, together with the unique business requirements of each industry, have created "spot" demand for workers with unique combinations of IT skills, experience and industry knowledge—expressed often by employers as needing "the right person, with the right skills, at the right time." The combination of time-sensitive competitive pressures and limited-time need for employees with unique combinations of technical skills, business skills, and hands-on experience has led many employers to pursue "buy" decisions in this labor market, rather than "make" decisions (to hire, then train for the task). Thus while there is a need to address the growing demand for highly-skilled IT workers, there is the additional challenge of meeting the unique demands of this niche labor market.

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In this report, we discuss the impact of the rapid creation and adoption of IT on the U.S. economy, describe the demand and supply trends for the core IT occupations (see boxes "Which Occupations Comprise the Core IT Work Force?" and "Descriptions of Core Information Technology Professions" on following pages), analyze indicators pointing to a tight IT labor market, provide a regional perspective, discuss the business environment and its impact on the IT labor market, and propose steps key stakeholders could take to help address this challenge.

In particular:

- Chapter II discusses the vital role of information technology in the U.S. economy, providing an overview of the forces driving the extraordinarily high demand for highly-skilled IT workers.
- Chapter III provides an analytical view of the business environment, how it is affected by information technology, and how it affects the labor market for the core IT occupations.
- Chapters IV and V of this report present an analysis of national demand and supply in the core IT occupations using government data sources.
- Chapter VI analyzes indicators pointing to a tight labor market for highly-skilled IT professionals.
- Chapter VII provides a state and regional perspective on supply, demand, and salaries.
- Chapter VIII recaps discussions at Office of Technology Policy-led town meetings and other fora focused on issues affecting the supply and demand for IT workers and ways to address the challenge.
- Chapter IX describes Federal initiatives designed to address the problem.
- The report concludes with several appendices containing supplemental data.

Which Occupations Comprise the Core IT Work Force?

What is an IT worker? It depends on whom you ask. In a broad sense, the term "information worker" can be applied to data entry personnel, auto mechanics who use computer diagnostic equipment, medical technicians who operate CAT scan equipment, and loan officers who use computers to assess creditworthiness, as well as computer programmers, systems analysts, and computer scientists and engineers.

For the purposes of this report, we have defined the core IT occupations as computer scientists (including database administrators, computer support specialists, and all other computer scientists), computer engineers, systems analysts, and computer programmers. We chose these occupational categories for several reasons.

First, Office of Technology Policy analysis shows that the difficulty in meeting the national demand for IT workers is primarily for those with higher-end skills. The core IT occupations are differentiated, generally, from other IT and IT-related jobs by significantly higher skill and educational requirements. A description of each occupation and its educational requirements is provided below.

Second, the ability to conduct a quantitative analysis of IT employment is limited, to a large extent, by the availability of data, especially consistent longitudinal data that enables analysis of trends. Through its Occupational Employment Survey, the Department of Labor collects employment data on the four IT occupations that comprise our definition of core IT workers, and uses that data for its biennial ten-year projections of occupational and industry employment. In addition, the Current Population Survey (CPS)—conducted jointly by the U.S. Department of Labor's Bureau of Labor Statistics (BLS) and the U.S. Department of Commerce's Census Bureau—provides data on core IT workers in two occupational categories: "computer systems analysts and scientists" and "computer programmers." While accounting for three of the core IT occupations, CPS data does not provide detailed information on the number of computer engineers.

The National Science Foundation does not consider computer programming as a science or engineering occupation, and therefore its Scientist and Engineer Statistical (SESTAT) data system does not fully account for the total number of computer programmers in the United States.

Descriptions of Core Information Technology Professions

Computer Scientists

Computer scientists generally design computers and conduct research to improve their design or use, and develop and adapt principles for applying computers to new uses. They are distinguished from other computer professionals by the higher level of theoretical expertise and innovation they apply to complex problems and the creation or application of new technology. Computer scientists employed by academic institutions work in areas ranging from theory, to hardware, to language design. Some work on multidisciplinary projects, such as developing and advancing uses for virtual reality. Computer scientists in private industry work in areas such as applying theory, developing specialized languages, or designing programming tools, knowledge-based systems, or computer games.

Included in the "computer scientist" occupation are database administrators and computer support specialists. Database administrators work with database management systems software, coordinating changes to, testing, and implementing computer databases. Since they also may be responsible for design implementation and system security, database administrators plan and coordinate security measures. Computer support specialists provide assistance and advice to users. They interpret problems and provide technical support for hardware, software, and systems. Support specialists may work within an organization or directly for a computer or software vendor.

Many others specialize in analysis, application, or design of a particular system or piece of the system. Network or systems administrators, for example, may install, configure, and support an organization's systems or portion of a system. Telecommunications specialists generally are involved with the interfacing of computer and communications equipment. Computer security specialists are responsible for planning, coordinating, and implementing an organization's information security measures.

Computer Engineers

Computer engineers work with the hardware and software aspects of systems design and development. Computer engineers may often work as part of a team that designs new computing devices or computer-related equipment. Software engineers design and develop both packaged and systems software.

Systems Analysts

Systems analysts use their knowledge and skills in a problem solving capacity, implementing the means for computer technology to meet the individual needs of an organization. They study business, scientific, or engineering data processing problems and design new solutions using computers. This process may include planning and developing new computer systems or devising ways to apply existing systems to operations still completed manually or by some less efficient method. Systems analysts may design entirely new systems, including both hardware and software, or add a single new software application to harness more of the computer's power. They work to help an organization realize the maximum benefit from its investment in equipment, personnel, and business processes.

Computer Programmers

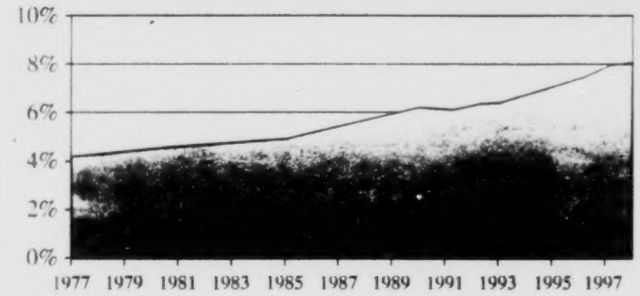
Computer programmers write and maintain the detailed instructions, called "programs" or "software," that list in logical order the steps that computers must execute to perform their functions. In many large organizations, computer programmers follow descriptions prepared by systems analysts who have studied the task that the computer system is going to perform. The transition from a mainframe to a primarily PC-based environment has blurred the once rigid distinction between the programmer and the user. Increasingly adept users are taking over many of the tasks previously performed by computer programmers. A growing number of sophisticated software packages allow users and systems analysts to write programs.

Source: Bureau of Labor Statistics, U.S. Department of Labor

II. THE VITAL ROLE OF INFORMATION TECHNOLOGY IN THE U.S. ECONOMY

The sweep of digital technologies and the transformation to a knowledge-based economy have created robust demand for workers highly skilled in the development and use of information technology. While there has been explosive employment growth in the U.S. software industry for more than a decade, the demand for workers who can create, apply and use information technology goes beyond the IT industry, cutting across manufacturing and services, transportation, health care, education and government.

FIGURE 1. Information Technology Sector's Contribution to U.S. GDP Has Grown Rapidly



SOURCE: U.S. Department of Commerce, Economics and Statistics Administration

Technology has contributed almost half of the Nation's long-term economic growth since World War II. And IT is the most important enabling technology in the world today. It is responsible for new products and services; creating new companies and industries; revitalizing existing products, services, and industries; providing new venues for commerce; enhancing our ability to manage information and to innovate; and improving our productivity, quality of life, and national standard of living. IT is changing the way we live and work, and transforming the economy at a fundamental level. The evidence is ubiquitous:

- Information technology's share of the U.S. economy nearly doubled between 1977 and 1998, growing from 4.2 percent to 8.2 percent (see Figure 1).[1]
- Information technologies contributed more than a third of real U.S. economic growth between 1995 and 1997.
- The cost of computing—measured in millions of instructions per second, or MIPS—fell 98.5 percent from $230 in 1991 to $3.42 in 1997.[2] And the price per MIPS is expected to fall below a dollar this year, and to about one-fifth of a cent within a decade.[3] This decline in computing costs is credited with reducing inflation by more than a full percentage point in 1997.[4]
- In 1994, three million people used the Internet.[5] Year-end 1998 figures indicate more than 147 million people worldwide were accessing the Internet at least once a week from home or business. The number of Internet users is projected to grow to approximately 320 million by 2000, and to 720 million by 2005.[6]
- Traffic on the Internet is doubling every 100 days.[7] This rapid growth in traffic is generating demand for both hardware and software, as well as for skilled IT workers to implement and manage these systems.
- Between 1998 and 2003, U.S. business-to-business commerce over the Internet is projected to grow from $48 billion to $1.3 trillion, with an additional $1.8 to $3.2 billion in global e-commerce; and U.S. consumer sales over the Internet are projected to rise from $3.9 billion to $108 billion.[8]

IT is changing the way we live and work and transforming the economy at a fundamental level.

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For years, economists have expressed skepticism about IT's contribution to economic growth and productivity improvements. In recent years, many economists have come around. Today, one of the Nation's leading economists, Federal Reserve chairman Alan Greenspan, is an enthusiastic supporter of the vital role of IT in the U.S. economy. Last year chairman Greenspan told a business audience in North Carolina, "The United States is currently confronting what can best be described as another industrial revolution. The rapid acceleration of computer and telecommunications technologies is a major reason for the appreciable increase in our productivity in this expansion, and is likely to continue to be a significant force in expanding standards of living into the twenty-first century."[10]

> *"The rapid acceleration of computer and telecommunications technologies is a major reason for the appreciable increase in our productivity in this expansion, and is likely to continue to be a significant force in expanding standards of living into the twenty-first century."*
>
> *Alan Greenspan*

III. THE BUSINESS ENVIRONMENT AND ITS IMPACT ON THE IT LABOR MARKET

Ways in which employers tap the labor market, and the decisions they make about hiring and training investments, are affected by the business environment in which they operate. Today, the business environment for IT product and service producers is having a significant effect on employer approaches to the recruitment, retention, and training of highly-skilled IT workers.

The Shift to Time-Based Competition

In the decades following World War II, the U.S. high technology enterprise was dominated by government spending in defense and space. Dominant employers of highly-skilled technical workers resided in industries characterized by product life cycles measured in years, not months, such as the defense and aerospace industries. Later, with the development of commercial computers, new IT industries began to play an important role in the labor markets for highly skilled technical workers, with the growth of computer hardware makers such as IBM, semiconductor manufacturers such as Texas Instruments and Intel, and service companies such as Electronic Data Systems. These large and stable firms had the time and incentive to serve as the training grounds for highly-skilled technical workers. Many of these workers then brought their knowledge and skills to small and medium-sized high technology firms connected to these industries, and founded and staffed the new entrepreneurial firms that fueled America's growing IT industry.

Today, the defense and aerospace industries have been downsized and are experiencing slow or no growth, and U.S. IT hardware manufacturers have globalized. At the same time, the computer and data processing services industry—consisting of software producers and IT consultants—has experienced a remarkable period of growth, with employment growing six-fold from 1976 to 1996. The employment growth in this industry is a product of the phenomenal demand for IT related-products and services that not only enhance the productivity of current operations, but also create new products, services, and firm capabilities. Software and its applications are often the critical driver of these improvements. Today, the computer and data processing services industry is, by far, the largest employer of highly skilled core IT workers, employing more than a quarter of all workers in these professions; in 2006, the industry's share is projected to rise to nearly 40 percent. Growth in science and engineering jobs is beginning to reflect this shift.

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Time is one of the most critical competitive factors for companies *for whom IT is their core business*. (This includes companies in the computer and data processing services industry, but also includes some business consulting firms, IT hardware producers, telecommunications companies, and others.) While product and technology life cycles have decreased markedly across all industry sectors, time pressures are most intense for these IT product and service producers. These companies confront life cycles or project deadlines that are measured in months or Internet years (when a couple of months is equal to a year). Keeping pace is critical.

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For example, at Hewlett Packard, new products earn their greatest revenue in their first year on the market and, by their second year, revenues are already tapering off. Nearly two-thirds of the company's revenues are generated from products less than two years old.[10] Moreover, early market entry provides a critical competitive edge. In many cases, the first competitors to the market with a new product are likely to capture most of the market share. For example, in some key areas of packaged software—Internet browsers, word processing, spread sheet, page layout, and e-mail— two producers account for the lion's share of the market. Competitors who are among the first to the market capture the critical flow of funds generated by those markets that is needed to pay the costs of developing the next generation of technology and products. Sometimes they become the de facto standard. If a company fails to reach the market in time, the lack of revenues to invest in development poses a serious risk that the company will eventually fall at the hands of more nimble competitors. The pressures of time-based competition are often felt more acutely by smaller firms which may lack the buffers that larger firms have, such as a broader product portfolio from which to generate revenues or a larger staff available for retraining and deployment to projects.

In industry segments characterized by fast-paced creators or innovators of IT products and services, jobs and companies change rapidly, with a high rate of creative destruction. In this group, a few firms will grow into large, dominating competitors. Some will be acquired by other firms. Many will die in the creative destruction process.

It is important to note that the development of software is highly labor-intensive. A principal way to accelerate software development is to devote more human resources to the process. In addition, rapid technological change makes it more difficult for companies to predict future resource requirements and introduces greater uncertainty into the business environment. Therefore, companies may not be able to ascertain their specific skill needs very far into the future.

Low Barriers to Entry Lead to Many Products and Services

Another major competitive factor concerns the production of *hardware* versus the production and application of *software*. Developing and producing high-tech hardware is highly capital intensive, requiring expensive manufacturing plants and other facilities. This is a relatively high barrier to entry into the business, a barrier that tends to limit the number of competitors.

In contrast, software development and application can be carried out from a home basement, with a few computers and desks. As a representative of Washington State's high-tech industry said, "All you need is a first month's rent and a computer and you're in business, and a lot of those 2,000 businesses [in Washington] are one and two persons." This low barrier to entry has allowed many competitors to enter the market with a rapidly growing array of products and services for different industries and consumer markets.

Time-based Competition and Product Proliferation Affect the IT Labor Market

Both the pressures of time, and product and service proliferation, play an important role in the market for IT workers. The critical element of time argues for hiring workers who already possess the needed technical skills and experience, who can work productively at once. Otherwise, when faced with a six-month product life cycle,[11] a training period as short as six weeks for a new IT worker or team represents one quarter of time-to-market. In that scenario, an employer risks missing the market window altogether and, thus, the stream of revenues needed to keep the company in high-tech competition. Similarly, an extended breaking-in period for an employee increases the chance that a customer's project deadline will not be met. Product proliferation creates the need for IT workers specialized in particular technical skills and their application. Taken together, time and product proliferation produce the demand for "the right worker, with the right skills, at the right time."

As a high-tech executive testified before Congress, "The information technology industry is advancing at a whirlwind pace; with product cycles and time-to-market periods shortening, and demands for continued innovation and productivity growing with each passing day. What we will offer next year has not been invented today. In this environment, you either get the right worker who can do the job and keep you ahead of the rest or you can call it a day."[12]

"What we will offer next year has not been invented today. In this environment, you either get the right worker who can do the job and keep you ahead of the rest or you can call it a day."

High tech executive in congressional testimony

IT Employers Face Different Environments

Among employers of IT workers, some focus on the development of new IT-related products and services, or perform projects under contract to other firms. These employers, *for which IT is the core business*, are the ones that must often contend with very short product life cycles and intense competitive pressures, or pressure from customers to bring projects in on time and within budget. Often, these employers, such as those in the computer and data processing services industry, have a high level of IT worker intensity in the work force.

Other employers of IT workers focus on the *application of information technologies to enhance their core businesses in other fields*, such as in insurance, banking, retail, or manufacturing. These firms have lower IT worker intensity, and typically enjoy longer life cycles in their use of information technologies.

These different types of IT employers confront different business challenges, which affect the way they recruit, retain, and invest in IT workers.

The Niche IT Labor Markets

The mix of knowledge and skills required can vary significantly from one IT job to another, in terms of the specific technical skills needed, industry knowledge and experience, and other qualifications in areas such as project management, communications, and organizational skills. Thus IT workers qualified for one job may not qualify for another. Certain technical skills may be in high demand or "hot," or be new skills—such as today's Java programmers, and computer security and e-commerce specialists—with employers having difficulty recruiting and retaining people with those skills. Also, IT is changing rapidly, which causes companies to frequently need different skill sets.

Competition for talent [is] especially intense for workers with specific "hot" skill sets, often in combination with appropriate experience.

Today's IT labor market appears to be tighter at the high-end, with the competition for talent especially intense for workers with specific "hot" skill sets, often in combination with appropriate experience. Those with hot skills are seeing fast rising salaries and commanding a salary premium above those whose skills are in less demand, more dated, or more generic. Those with multiple hot skills and relevant industry experience are seeing especially fast rising compensation.

Many employers, especially those for whom IT is their core business, demand job candidates with exact skill fit, requiring no additional training. Faced with short product life cycles, customer deadlines, and competitive pressures that leave no time to spare, such employers want workers with the right skills and experience who can be productive right away. With numerous combinations of technical skill sets and fields of experience, part of the IT labor market appears to operate as a series of niches requiring specialized, higher skill sets. Even if a company receives many resumes from which to choose to fill its job, the right candidate, with the right skills and experience may not be in the resume mix. This results in low selection rates. For example, one IT company had hired 1,000 engineers after receiving 22,000 resumes, or a selection rate of about 4 percent.[13] A technical recruiter lamented that they had gotten 300 applicants at an IT job fair, yet did not find anyone qualified for the job for which they were recruiting.[14]

Brian Jaffee from *PCWeek* described it this way:

> "It is not about the size of the IT labor pie. Instead, it's a reflection of the fact that there are so many ways to slice that pie, that hiring managers may only be left with a crumb after they carve out their needs.
>
> For example, a database administrator is not simply a DBA. There are different database products—Oracle and Informix, for example. Each has several versions in widespread use and different versions of those offerings for different technology platforms and operating systems. If you prefer a DBA who has experience with other key technologies in your environment, your options are further reduced.

Perhaps you want specific project experience, say, building a data warehouse. Throw in other parameters such as environment size, industry, years of experience, communication or supervisory skills, certification, and salary range, and the grains of sand quickly slip through your fingers."[15]

The Make vs. Buy Decision

As time has become an increasingly important factor of competitiveness for many employers of IT workers, the time available to retrain existing employees or train new employees in the skills needed for new projects has diminished. In its recent report on the supply of IT workers, the Computing Research Association (CRA) states that "companies are forced by short product life and short product development cycles to hire new employees or reassign existing workers in ways that do not require a lot of break-in training before they can be productive." Or as the president of an Arizona IT company put it, "I am afraid as an employer of getting people who would require an awful lot of training. We have eight hours to learn a new system. We don't have three months or six months."

"I am afraid as an employer of getting people who would require an awful lot of training. We have eight hours to learn a new system. We don't have three months or six months."

Arizona IT company president

In this environment, many companies have concluded that they cannot afford the time penalty and the uncertainty associated with "making" the employees they need (through training or retraining). Many employers are, instead, pursuing a "buy" strategy, seeking the exact skills and experience they need for a particular project and paying a premium for that. Or, as reported by the Gartner Group, "the pace of technological change is making the outside market the best source and repository of intensive technology skills."

Only 15 percent of IT hiring managers polled in a *Computerworld* survey said that "promote from within/train in-house" was the most effective method for acquiring needed skills and people. The rest indicated some form of outside recruitment was most effective, led by placement firms and headhunters (37 percent), and followed by newspaper and magazine ads (17 percent), referrals from peers/contacts (17 percent), and Internet ads (14 percent).

The CRA report acknowledges the need for looking outside the company to find the required technical skills, saying that the business environment "makes it difficult to retrain an existing employee for a significantly different job. Thus employers are sometimes forced, by competitive pressures, to lay off workers of one type and hire workers of another type. Or they may refuse to hire anyone who does not already possess the needed skills. These employer practices receive harsh criticism at times from labor unions and some government officials, but to some degree this is a rational and perhaps necessary reaction to the realities of the marketplace."

One such criticism came in the *Information Week* article, *Labor Shortage? Look Harder*. "The vast majority of companies do little to train people to fill IT positions or reassign senior people—they treat filling IT jobs like buying PCs, looking to fill a specific spec sheet for the lowest price."

There is, of course, a time risk associated with seeking to recruit and hire the candidate with the exact skills and experience, especially in a tight labor market. Outside hires also lack important, company-specific knowledge, and may be less committed and loyal to the employer.

Companies also pursue buy decisions for other reasons. First, in fast-growth IT companies, often every core IT worker is deployed on current projects leaving none available for retraining. Second, in a dynamic, fast paced, highly competitive environment such as IT, the technology paths are often uncertain, making it very difficult to project future skill needs.

> *"The vast majority of companies do little to train people to fill IT positions or reassign senior people—they treat filling IT jobs like buying PCs, looking to fill a specific spec sheet for the lowest price."*
>
> *Information Week*

Though the "buy" strategy generally requires paying a premium for the requisite skills, companies are able to reduce the risks associated with the uncertainty about their future skill needs, while reducing or even eliminating the cost of training. At the same time, employers can be reasonably assured that new hires are able to hit the ground running.

Other Disincentives to Train

As with other investments, companies generally invest in training because of the returns it brings through improved performance. However, the current IT business environment and its effect on the highly-skilled IT labor market increase the risk of training investments and reduce the likelihood of capturing an acceptable return on the investment.

The tight IT labor market—a function of both the rapid demand for core IT workers, generally, and the need to fill specific niches— has created an environment in which many companies seek to find the people they need by luring talented IT workers away from their current employers using a variety of mechanisms.

These inducements (in the form of compensation, benefits, and better quality of working life conditions) encourage job-hopping among IT employees, creating another major disincentive for companies to train or retrain workers. Companies that invest in the training of employees to upgrade their IT skills may create an attractive target for poaching by other companies, putting at risk both the employees and the companies' training investment.

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Employers who apply information technologies in support of their core businesses in other fields often have more stable employment environments and longer IT life cycles and, thus, have greater ability to "make" their skill base by investing in training. However, since they share the same labor pool with firms whose core business is IT, they are buffeted by the actions of others. They, too, risk poaching of their employees and may also have to pay premiums to acquire and retain certain IT skills, especially the ones most in demand.

Why, then, do some companies offer training and education to their IT employees? In some companies, training and education are offered as ***benefits*** to employees (to attract or retain them) who understand they must keep their skills current if they are to remain viable in the IT labor market.

"I would tell you that it is an absolute necessity for companies to train. My employees are going to leave if I do not train them. If I don't find better ways of getting them involved in new and emerging technology, they are going to leave my organization," said the vice president of a Maryland company, adding, "They are highly motivated to stay on the edge, to move forward, to have new opportunities. Their career is more in expansion of their view of the technical area, rather than moving up a corporate ladder."

> *"I would tell you that it is an absolute necessity for companies to train… My employees are going to leave if I do not train them."*
>
> *Maryland company vice president*

Recruitment and Retention

As many companies have turned to a buy strategy to gain the critical skills they need, they have undertaken a wide range of strategies to attract and retain workers—from the commonplace to the extraordinary.

Unlike so many occupations in which job stability is a hallmark of success, the business environment in IT has created a labor market in which job hopping serves as a means to gain the vital technical skills needed for career opportunities.

Research by the Computing Research Association supports this finding, "Jobs are now regarded as another element of the training process, of learning by doing, and employees move from job to job to gain new skill sets and experiences rather than assume they will stay with a particular company for life. Acquiring new skills allows them to move within the entire IT work community for opportunities, rather than solely within a particular company."

The impact can be seen in how quickly IT workers move from one employer to the next, and how intensely they are recruited. *Information Week* reports that the average job length is four years for IT staffers and five years for IT managers. Not surprising, says the publication, since its survey also showed that more than two-thirds of IT professionals have been contacted by a headhunter in the past year—an average of three times each in just the past six months. The recruitment is even more intense for the hot skills. For example, three out of four staff members, and nine out of ten managers in data mining report being contacted by recruiters in the past year. And in super hot Silicon Valley, the average length of stay at a single job is 18 months, according to *Digital Nation*.[16]

In an *Information Week* salary survey, IT workers ranked "challenge of their job, responsibility" and "job atmosphere" ahead of "base pay" as what mattered the most to them about their jobs. Quality of working life issues, job stability, and having the opportunities to gain critical skills through job assignments dominated the responses. This is consistent with the preliminary results of a study conducted by researchers at Drexel University and Rider University that indicates IT workers tend to rate career development and nonmonetary compensation as more important to their job satisfaction than money.[17] Still, monetary compensation ranks high among the tools used by companies to recruit and retain employees. Among the more common tools employed: signing/performance bonuses, salary premiums for hot skills, stock options, referral fees, royalty fees, child care, flexible hours, telecommuting, training and education, tuition reimbursement, time off/extra vacation time, gyms and exercise facilities.

> *IT workers tend to rate career development and nonmonetary compensation as more important to their job satisfaction than money.*
>
> *Drexel University and Rider University study*

Sometimes, though, getting—and keeping—"the right person, with the right skills at the right time" requires extraordinary efforts and innovative practices:

- CareerBuilder Inc. wanted a particular graphical user interface design expert so much, they paid to convert his barn in West Virginia into a state-of-the-art telecommunications center that enables him to direct a team at the company's headquarters in Reston, Va., and fly him in for regular staff meetings.[18]
- America Online Inc. recently announced that it has established a three-person company concierge to handle "anything you'd be worrying about and would have to do at lunch," including making restaurant reservations, taking a car to the repair shop, or shopping for a birthday present.
- One Virginia-based company offered $250 to anyone invited to interview with the company; 800 people responded within a week.[19]
- The Work/Life Department of the SAS Institute, a Cary, N.C.-based software company, helped an employee's teenage son stop smoking and also found a beach house for a terminally ill employee to spend her last days. SAS attributes its less than four percent turnover in 1997 to such policies, including providing discounted child care at its headquarters.
- Kraft Foods attributes its reduction in annual IT staff turnover to five percent to its focus on community building and personal development. The company encourages its employees to pursue education and training beyond technology, including areas such as business and finance.[20]
- Sun Microsystems offers adoptive parents financial assistance of up to $2,000; lactation rooms for nursing mothers returning to work; a special day care center in the San Francisco Bay Area that accepts children with minor illnesses; a dependent care spending program; a consultation and referral program; and an employee assistance program that offers short-term professional counseling, as well as other benefits.

Time to Seat

Much has been said about the reported high rates of vacancies in IT companies and other IT-worker intensive organizations. Vacancies are a normal part of business, the result of turnover and the time it takes to fill a job. In industries and occupations that are experiencing sustained, rapid growth, and relatively high rates of labor mobility, vacancies should not be surprising. If it takes between 35-70 days to fill different positions, and the company is experiencing rapid growth, and if a specialized type of employee is being sought, vacancies are to be expected. A tight labor market compounds the challenge.

Not all employers of IT workers enjoy a well-oiled and nimble human resources department, with sophisticated and creative recruitment methods, and a streamlined hiring process. Many small companies do not have human resource departments at all, and hiring functions may be performed by technical professionals who have little or no knowledge and experience in human resources practices. Many companies contract with recruiting firms to fill their jobs, but many of these recruiters lack the technical knowledge to do much more than follow the technical specification the hiring firm provides.

Making the labor markets work better—in terms of effectively identifying the critically needed skills, rapid identification of potential candidates, and streamlining the internal hiring process—could help reduce the time it takes to staff operations and reduce vacancy rates.

In industries and occupations that are experiencing sustained, rapid growth, and relatively high rates of labor mobility, vacancies should not be surprising.

State Recruitment and Retention Efforts

Finally, it should be noted that recruitment of skilled IT workers is not limited to companies. Many states see a highly-skilled IT work force as a major tool to encourage economic development.

As a result, some states and regions have instituted efforts to lure people away from other regions of the country.

For example, the State of Michigan launched its "Come Home to Michigan" campaign to attract IT workers who grew up in Michigan or were educated there. The Minnesota High Technology Association, in partnership with the Minnesota Department of Economic Security, conducted a five month "Upgrade to Minnesota" ad campaign in Silicon Valley to introduce workers there to the advantages of Minnesota living. The campaign reportedly generated thousands of resumes of technical and scientific workers for the sponsoring companies.

The loss of skilled IT workers to others is also a concern of economic development officials. For example, the Hudson Valley, New York area is losing IT professionals to contract work for employers in other areas. It was noted at the Hudson Valley town meeting that the northern New Jersey market pays IT professionals 10 percent more and the New York City market pays 25 percent more.

Others see information technology as a tool to keep the residents from moving to other states for job opportunities. U.S. Senator Kent Conrad expressed his concern about the isolation of small towns around the country stating, "There is a need to keep the best and brightest in North Dakota. This is the biggest concern of parents. IT is an opportunity to provide these jobs."

"There is a need to keep the best and brightest in North Dakota. This is the biggest concern of parents. IT is an opportunity to provide these jobs."

U.S. Senator
Kent Conrad

H-1B, The Issue of Temporary Foreign Workers

Some employers of IT workers are looking to foreign workers to meet their skill needs. Whether or not to allow larger numbers of skilled foreign workers to enter the country in order to meet employers' demands for new IT workers is a contentious issue. A debate has focused on the allowable number of H-1B visas, which allow skilled foreign workers to work in the United States for up to six years. Although H-1B visas are "non-immigrant" visas, they are often used as a stepping stone to permanent immigration. In some cases, foreign students enter the United States on a student visa, receive an H-1B visa after graduation, and then seek permanent employment-based immigration. Nearly half of the people who become permanent employment-based immigrants convert from H-visa non-immigrant status.[21]

Prior to 1998, the number of H-1B visas had been capped at 65,000 workers per year. The IT industry has increasingly used H-1B visas. In 1995, only about a quarter of temporary skilled foreign workers were in IT-related fields; by 1997 about half were in IT fields.[22] Largely due to the increased use by the IT industry, the H-1B cap was reached for the first time in August 1997. In 1998, the cap was reached in May.

The IT industry led a major effort to increase the H-1B visa cap.[23] They argued that:

- the IT industry needs more skilled foreign workers to help meet skill shortages,
- an inability to find workers has limited growth in the IT industry and other parts of the economy that need IT workers,
- the IT industry needs an international work force to meet the needs of international markets,
- the IT industry needs to be able to attract the best and brightest workers from around the world, and
- the alternative to bringing foreign workers to the United States is to move work overseas.

Groups that represent U.S. scientists, engineers, and other technical workers have opposed expansion of the H-1B program, arguing that:[24]

- there are Americans who can do the work but industry wants lower cost labor,
- the availability of H-1B workers reduces the incentive for employers to hire older U.S. unemployed and underemployed engineers or to actively recruit women and underrepresented minorities,

- H-1B workers cause wages in IT occupations to be lower than they would otherwise be, reducing the incentive for U.S. residents to enter, or stay in, these occupations; thus immigration can create a self-perpetuating demand for more immigration, and
- the H-1B program has been abused by firms, which have brought in foreign workers to work at less than the prevailing U.S. wages.

In late 1998, the Congress and the White House agreed to compromise legislation that would temporarily increase the H-1B cap and also attempt to curb abuses in the program.[25] The legislation raises the H-1B cap to 115,000 for fiscal years 1999 and 2000, and then decreases it to 107,500 in 2001, and 65,000 in 2002. The law also provides for the collection of a $500 fee for each H-1B application in order to create a fund for low-income student scholarships and training programs. The National Science Foundation will administer the newly established Computer Science, Engineering and Mathematics Scholarship Program, providing student scholarships to enable the achievement of higher education degrees in IT-related disciplines. The law also includes new provisions intended to prevent abuses of the program. For example, H-1B dependent employers (generally those for whom H-1B visa holders are more than 15 percent of their work force) must attest that they are not laying off U.S. workers for similar jobs and that they have made significant efforts to recruit U.S. workers.

In the midst of a tight labor market, there are numerous anecdotes of middle-age technical workers having difficulty finding IT jobs.

Mid-Career Technical Workers

In the midst of a tight labor market, there are numerous anecdotes of middle-age technical workers having difficulty finding IT jobs. Data from the National Science Foundation indicate, however, that the employment profile for computer and math scientists closely parallels that of the overall science and engineering work force. (Table 1) It is important to recognize that the IT industry is young and fast growing compared to many other industries and, thus, has a younger worker demographic profile which may contribute to the perception that it is not a hospitable environment for mid-career workers. For example, 89 percent of those receiving Microsoft Certified Professional credentials are under the age of 44.

The difficulties faced by mid-career technical workers have been widely reported in IT magazines[26] and this issue was raised at several of the town meetings. There are a number of reasons mid-career technical workers may face barriers in the IT labor market.

- The IT industry is populated by many younger workers. Approximately 75 percent of computer systems analysts and scientists, and nearly 80 percent of computer programmers are under the age of 45.[27] Many managers in the IT industry are in their 20s and 30s, and may be uncomfortable hiring or managing older and more experienced workers. A *Network World* survey of 200 readers with some hiring responsibility showed that younger network managers are less likely to hire older workers than younger workers. Almost half of respondents 20 to 30 years of age had never hired a person over the age of 40.[28]

Many mid-career workers have a breadth of experience that could benefit many young IT companies.

- Many IT companies have operating modes that require long and intense work hours, and mid-career workers, for example those with family obligations, may be assumed to be unwilling to work these long hours (although they may in fact be willing).
- Some employers may hold the perception that mid-career workers expect higher pay for doing the same work that younger workers do.
- There is a perception that mid-career workers may not be current with the latest skills, may not be as flexible in doing different kinds of work, and may be less innovative, compared to younger workers.
- Some employers may have concerns that mid-career workers will cost the company more in insurance premiums, due to age and higher likelihood of having covered family members.

On the other hand, many mid-career workers have kept up with the latest skills (or could easily obtain them), are innovative, and are willing to work long hours for market pay rates. Many mid-career workers have a breadth of experience that could benefit many young IT companies.

Some mid-career unemployed and underemployed engineers may find difficulty in obtaining employment because they expect higher wages or, while they may be highly-skilled and experienced, they may not have the specific technical skills that employers want. On the other hand, it is likely that some mid-career engineers who have appropriate skills and are willing to work at market wages are overlooked because of the perception—not the reality—that older workers cannot do the job.

It should also be noted that many of the IT jobs that are the hardest to fill are those in non-IT industries, in government, and in schools. Many of these types of organizations do not seem to have the same youth-oriented culture that characterizes many entrepreneurial software companies, and would welcome mid-career technical workers.

The *1998 American Competitiveness and Workforce Improvement Act*, which increased the number of skilled non-immigrant foreign workers allowed to work in the United States, requires the National Science Foundation to contract with the National Academy of Sciences to conduct a study assessing the status of older workers in the IT field, including a consideration of the existence and extent of age discrimination in the IT work place.

TABLE 1. Employment, Unemployment, and Not-in-Labor Force Rates for Computer and Math Scientists, Overall S&E Work Force

Age Group	Total	Employed	Unemployed	Not In Labor Force
Computer and Math Scientists				
<30	152,400	94.7%	1.4%	3.9%
30-39	386,600	93.1%	1.2%	5.7%
40-49	310,600	93.4%	1.5%	5.0%
50-59	196,400	88.5%	1.8%	9.7%
60+	90,100	38.8%	1.9%	59.3%
Total Scientists and Engineers				
<30	1,696,700	87.2%	2.1%	10.7%
30-39	3,380,000	93.0%	1.1%	5.9%
40-49	4,058,600	93.7%	1.4%	4.9%
50-59	2,451,400	90.3%	1.5%	8.2%
60+	1,742,200	42.7%	1.7%	55.6%

Data is for highest degree earned

SOURCE: National Science Foundation, SESTAT database

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Temporary and Contract Employees

In an uncertain business environment, faced with rapid technological change, many employers seek flexible means of staffing their projects. Employers use independent contractors or temporary workers employed by staffing companies (temp agencies) as a mechanism to meet their need for IT workers in this dynamic environment. In the case of contract workers, the workers are not considered to be employees and are responsible for paying their own payroll taxes and unemployment insurance.[29] In the case of temporary workers, the staffing companies are responsible for their employees' wages and legally required payroll deductions, and may provide some benefits as well.

Using either independent contractors or temporary workers has advantages for the employer. Employers can get the specific skills they need for a temporary project without hiring people that might need to be laid off later. Employers can also check out people on a trial basis before deciding whether or not to hire them. And companies do not have to pay (at least not directly) for expensive benefit packages.

Contract or temporary work can also be advantageous to some employees. Independent contractors with skills in high demand can get paid at a higher rate than most employees, and some workers desire the greater flexibility and variety that can come from temporary or contract work. Temporary work may also let employees gain work experience that may make them more marketable. On the other hand, many employees who accept such arrangements may prefer to have permanent employment.

The IT industry has been expanding its use of various types of temporary workers. According to the National Association of Temporary and Staffing Services, total wages paid for assigned technical workers (a category that includes computer programmers, computer systems analysts, designers, drafters, editors, engineers, and illustrators) grew from $1.9 billion in 1991 to $4.7 billion in 1998.[30]

The increasing use of temporary workers has implications for the training of IT workers. When a company uses temporary or contract workers, it is generally purchasing skills for immediate use, and has little or no motivation for investing in training for that worker. The incentive and responsibility for investing in training lies clearly with the individual worker, and, to some extent, with the temp agency. Temp agencies do invest in training. A 1998 survey by the National Association of Temporary and Staffing Services indicated that staffing firms expended $720 million for skills training in 1997, training 4.8 million individuals.[31]

When substantial numbers of temporary workers work for a single company for a long time, it creates a class of workers known as "permatemps." This kind of arrangement, although increasingly popular, has been thrown into question recently by the U.S. Court of Appeals for the Ninth Circuit, which ruled that independent contractors or temporary employees placed by agencies are entitled to the same benefits that permanent staffers get.[32] The ruling resulted from suits by independent contractors at Microsoft Corporation who were seeking participation in Microsoft's Employee Stock Purchase Plan.[33]

The Court of Appeals panel held that workers who are employed by a temp agency can also be considered common-law employees of the company that directs their work, and, as such, are entitled to participate in company benefits. This ruling will clearly make long-term employment of workers through temp agencies more expensive and less attractive to employers, and is likely to slow the use of independent contractors and temporary workers.

When a company uses temporary or contract workers, it is generally purchasing skills for immediate use, and has little or no motivation for investing in training for that worker.

Outsourcing

Outsourcing technical skills should allow the proliferation of technical consulting companies and staffing operations that can offer (because of increased economies of scope and scale) a wider range of opportunities to individuals. These operations should also be able to capture a greater return on investments in training because they can provide better career paths for technical employees, focus their retention practices, and provide internal mobility, thereby reducing turnover.

IV. THE DEMAND FOR CORE IT WORKERS

Overview

As information technology has emerged as a fundamental driver of global business and economic growth, there has been explosive growth in the demand for IT professionals. For more than 15 years, employment in the core IT occupations— computer scientists, computer engineers, systems analysts and computer programmers—has grown at an astounding pace. The growth rate for computer scientists and systems analysts has even accelerated in recent years.

In addition, employment in the computer and data processing services industry[53] —which employs the largest number of IT workers and has the highest proportion of IT workers in its work force—has experienced rapid employment and revenue growth.

For more than 15 years, employment in the core IT occupations— computer scientists, computer engineers, systems analysts and computer programmers—has grown at an astounding pace. The growth rate for computer scientists and systems analysts has even accelerated in recent years.

Employment in the Core IT Occupations

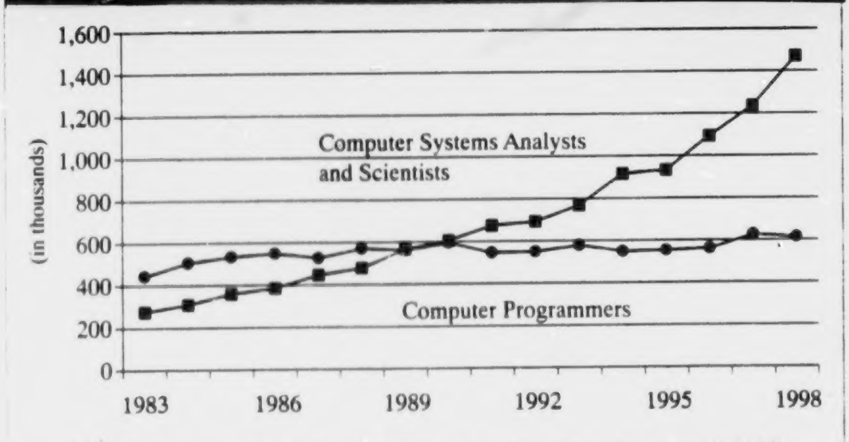
Rapid, Steady Long-term Growth

There are several government data sources on employment in the core occupations. The collecting agency, methodology, strengths and weaknesses of each are discussed in the box, "Government Statistical Sources of Information." (see page 23)

There is agreement among these data sources that the number of core IT workers in the United States has grown rapidly and steadily during the past fifteen years. Though there is not unanimity among the data sources on the size of the core IT work force, 2.1 million in 1998 appears to be a reasonable estimate (see box "How Many Core IT Workers Are There in the U.S. Work Force," page 24).

Between 1983 and 1998, data from the Current Population Survey (CPS)—a joint project of the U.S. Departments of Commerce and Labor—shows the number of "computer systems analysts and scientists"—which includes computer engineers— and "computer programmers" soared from 719,000 to 2,084,000, an increase of 190 percent, more than six times faster than the overall U.S. job growth rate of 30.4 percent. Computer systems analysts and scientists have shown the most rapid growth, 433 percent, during this period. In contrast, computer programmers grew by 38.4 percent, much closer to the overall U.S. job growth rate (see Figure 2).

FIGURE 2. Employment in Core IT Occupations Current Population Survey, 1983-1998



SOURCE: Department of Labor, Bureau of Labor Statistics, Current Population Survey 1983-1998

Recent trends

Though the overall job growth rate for the country has remained steady, the core IT occupations have grown at an even faster rate in recent years than for the 15-year period. Annual average growth for computer systems analysts and scientists was 11.8 percent and 2.2 percent for computer programmers during the 1983-1998 period, according to CPS data. Between 1995 and 1998, computer systems analysts and scientists recorded an annual average job growth rate of 16.4 percent, while computer programmers scored a 3.7 percent annual average job growth. Thus employment growth for IT occupations seems to be even stronger in recent years than in the past.

Government Statistical Sources of Information

Current Population Survey (CPS)

Source: A joint project of the U.S. Department of Labor's Bureau of Labor Statistics (BLS) and the U.S. Department of Commerce's Census Bureau.

Data collection method: Each month, CPS conducts face-to-face interviews with one representative at each of 47,500 households, who supplies information on occupations for everyone at that location.

Strength: Most current data on the work force.

Weakness: Secondhand collection of information; results might vary if each jobholder in the household identified his/her own occupation. CPS interviewers are trained to deal with this problem, but Census Bureau staff acknowledges limitation.

National Industry-Occupation Employment Matrix (I-O Matrix)

Source: Developed by the Bureau of Labor Statistics as part of its ongoing Occupational Employment Projections Program. The 1996 matrix was developed primarily from the Occupational Employment Statistics (OES) survey, the Current Employment Statistics (CES) survey, and the Current Population Survey (CPS). The source of base-year employment in each matrix industry is the Current Employment Statistics survey. Staffing patterns for industries in the base-year matrix for wage and salary workers are based on data from the Bureau of Labor Statistics' Occupational Employment Statistics survey of establishments. The Industry-Occupation Matrix uses the occupational classifications used in the OES survey. Data for agriculture (except agricultural services), forestry and fishing, private households, self-employed workers, and unpaid family workers come from the CPS data.

Data collection method: The Occupational Employment Statistics program conducts a yearly mail survey of approximately 400,000 establishments. The data collected is used to produce estimates of occupational employment and wages for over 750 occupations in more than 400 industry classifications.

Strength: It is the only well-established source for forecasts of occupational trends with very detailed breakouts for occupations and industries.

Weakness: Lack of recent data—the most recent edition of the matrix was released in late 1997 and provides data for 1996 plus projections to 2006.

Methodological Change: Through 1995, OES collected data over a three-year cycle, surveying all establishments in a third of the industries each year. In 1996, OES began collecting data for all industries each year, surveying a third of all establishments in each industry each year. As a result, OES survey data for 1997 are not strictly comparable with the 1996-2006 Employment Projection series. When the 1996-2006 employment projections were developed, the 1996 OES employment numbers were not available. In addition, certain core IT occupations were only added to the survey in 1994. Therefore, the 1996 occupational employment matrix is the estimate developed from the data available at the time. As a consequence, the expansion or contraction of employment (e.g. number of workers) for the various occupational categories between 1996 and 1997 may be due to combinations of methodological refinements and real population changes.

Scientist and Engineer Statistical Data System (SESTAT)

Source: The National Science Foundation, using a combination of three separate surveys: the National Survey of College Graduates, National Surveys of Recent College Graduates, and the Survey of Doctorate Recipients

Data collection method: These surveys are conducted using a mix of mailed questionnaires and telephone interviews. Data from each are then combined to yield estimates for the entire scientific and engineering workforce. The SESTAT database is updated every two years.

Strengths: All data is from first-hand sources; each person in the SESTAT database has been contacted directly. SESTAT contains information on many characteristics of IT workers, and supports the production of special tabulations for specific research projects.

Weaknesses: Lack of recent data—the most recent SESTAT data is 1997. In addition, there are gaps in SESTAT's coverage of IT workers. The database does not include persons who do not have a U.S. bachelor's degree or experience before 1990 in a science or engineering job. The SESTAT database also omits those with non-science or non-engineering bachelor's degrees earned after 1993 and who did not have jobs in science or engineering before April of that year. NSF does not consider programmers to be scientists or engineers, so SESTAT yields only a partial count of those workers, limited to people with a bachelor's or higher degree (and as noted above, not everyone with those degrees is included). For this reason, CPS provides a better estimate of the number of programmers than SESTAT.

How Many Core IT Workers Are There in the U.S. Work Force?

A Comparison of Government Data Sources

There are three primary Federal government data sources for information about the U.S. information technology work force—the Current Population Survey (CPS), the Industry-Occupation Employment Matrix (I-O Matrix), and the National Science Foundation's Scientist and Engineer Statistics (SESTAT) data system. Each source uses different methodologies for collecting data and arriving at estimates of the number of these workers (see box "Government Statistical Sources of Information, page 23). Despite the different methodologies, there is general agreement that the size of the core IT work force in 1998 was approximately 2.1 million.

Table 2, "Government Estimates of the Number of Core IT Workers in the United States," provides a comparison of the counts each government data source provides on core IT workers. The data is quite consistent, with relatively minor discrepancies accounted for by differences in survey methodologies, disparities in the universe of workers covered in each database, and the categorization of occupations (see "Notes" column in Table 2).

Comparing the 1996 I-O Matrix (the most current data) with the 1996 Current Population Survey. The CPS estimate of 1,093,000 computer scientists, computer engineers and systems analysts (under its occupation title "Computer Systems Analysts and Scientists") is about 17 percent higher than the I-O Matrix estimate of 933,000. In the "Programmer" category, though, there is virtual agreement with estimates of 568,000 for the I-O Matrix, and 561,000 for CPS.

Comparing the 1997 SESTAT data (the most current data) with the 1997 Current Population Survey estimate of core IT workers. The CPS estimate of 1,236,000 computer scientists, computer engineers and systems analysts (under its occupation title "Computer Systems Analysts and Scientists") is about 23 percent higher than SESTAT's estimate of 1,003,400. This is accounted for, at least in part, by the fact that the SESTAT database captures only college graduates while CPS data shows that a third of core IT workers do not hold college degrees. In the "Programmer" category, the discrepancy is larger, with CPS estimating 626,000 programmers versus 189,500 for SESTAT. This large variance in the count for programmers is expected since SESTAT does not treat programming as a science or engineering field, and therefore does not account well for programmers.

1998 CPS annual average household data shows that there were 2,084,000 core IT workers—1,471,000 computer systems analysts and scientists, and 613,000 programmers.

TABLE 2. Government Estimates of the Number of Core IT Workers in the United States

Year and Source	Computer Scientists, Computer Engineers & Systems Analysts	Programmer	Total	Notes
1996 Current Population Survey	1,093,000	561,000	1,654,000	Some computer engineers are captured in "Computer Systems Analysts and Scientists" occupation, though others (not accounted for in this table) are captured under the occupational title "Electrical and Electronic Engineers."
1996 I-O Matrix	933,000	568,000	1,501,000	Many information technology-related managers are captured in the category "Managers and Administrators, n.e.c." and not accounted for in this table.
1997 Current Population Survey	1,236,000	626,000	1,862,000	See note for 1996 CPS data.
1997 SESTAT	1,003,400	189,500	1,192,900	College graduates only. Programming is not treated as an S&E field by NSF. Includes computer science professors.
1998 Current Population Survey	1,471,000	613,000	2,084,000	See note for 1996 CPS data.
2006 I-O Matrix Projections	1,937,000	697,000	2,634,000	Computer systems managers are captured under the occupation "Managers and Administrators," of which 498,000 are engineering, science and computer systems managers. Computer systems managers are not accounted for in this table.

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Projected Employment Growth in the Core IT Occupations

The number of core IT workers is projected to grow dramatically between 1996 and 2006 (see Figure 3). The Office of Technology Policy's analysis of the Bureau of Labor Statistics' growth projections for this period [34] shows that the number of core IT workers—computer scientists, computer engineers, systems analysts and computer programmers—will grow from 1.5 million in 1996 to 2.6 million in 2006, an increase of 1.1 million. In addition, another 244,000 workers will be needed to replace those exiting these professions.

Thus, during this period, the United States will require more than 1.3 million new highly skilled IT workers in these occupations—an average of about 137,800 per year—to fill newly created jobs (1,134,000) and to replace workers who are leaving these fields (244,000).

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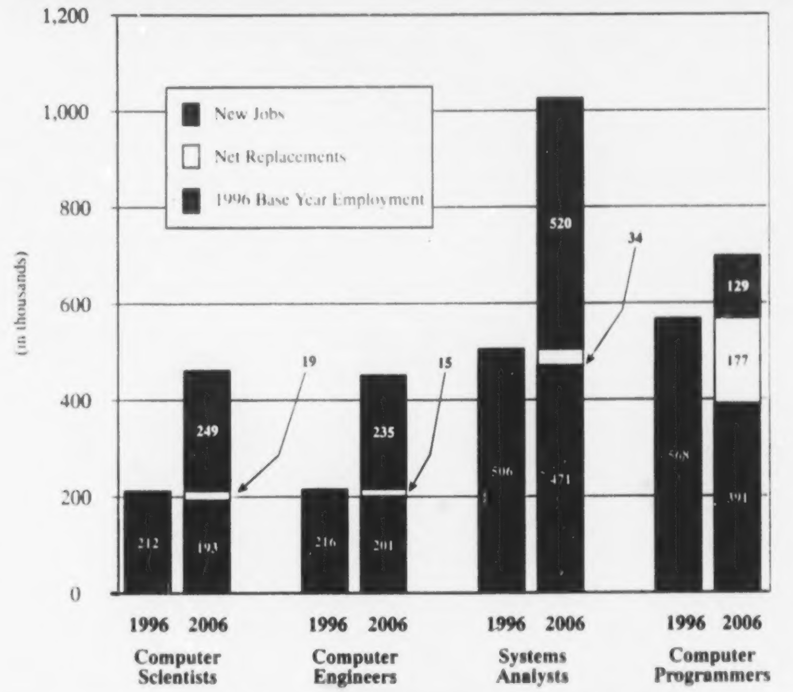
FIGURE 3. Strong Growth Projected for Core IT Occupations Through 2006



SOURCE: U.S. Department of Commerce analysis of Bureau of Labor Statistics employment projections 1996-2006

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IT Occupations Have Fastest Projected Growth Rates

The three fastest growing occupations in the 1996-2006 employment projections are core IT occupations. Computer scientists, computer engineers, and systems analysts are each projected to more than double during this period. By comparison, the growth rate for all occupations is 14 percent. (see Table 3) No other occupation tops the 100 percent growth rate; in fact, the next closest—personal and home care aides—has a growth rate of 85 percent.

Computer scientists[35] are projected to grow from 212,000 in 1996 to 461,000 in 2006, a jump of 118 percent; computer engineers from 216,000 to 451,000, a 109 percent increase; and systems analysts from 506,000 to 1,025,000, a 103 percent increase. While the number of computer programmers will grow more slowly—from 568,000 in 1996 to 697,000 in 2006, a 23 percent increase—a large number of new programmers—177,000—will be required to replace those exiting the occupation. (see Figure 3 and Table 4)

Reasons for the comparatively slow projected growth rate in computer programming employment (as well as past slow growth rates as indicated by CPS and I-O Matrix data) are discussed in the box "Underlying Reasons for Comparatively Slow Growth for Computer Programmers."

TABLE 3. Fastest Growing Occupations, 1996-2006

Occupation	Projected Growth Rate
1. Computer Scientists	118%
2. Computer Engineers	109%
3. Systems Analysts	103%
4. Personal & home care aides	85%
All Occupations	14%

SOURCE: U.S. Department of Labor, Bureau of Labor Statistics, 1996 Industry-Occupation Employment Matrix

Systems Analysts Add Largest Number of High Wage Jobs

In addition to these fast growth rates, systems analysts are expected to record the second highest growth in numbers, adding 520,000 workers during this period. In terms of gross numbers, systems analysts are exceeded only by cashiers. Cashiers' earnings, however, rank in the bottom quartile of all occupations. Thus, for high wage jobs, systems analysts have the largest job growth.

TABLE 4. Employment Projections for Core IT Occupations

Occupation	Employment		Change, 1996-2006		Net Replacements	Total Job Openings
	1996	2006	Number	Percentage		(Growth and Net Replacement)
Computer Scientists	212	461	249	118%	19	268
Computer Engineers	216	451	235	109%	15	250
Systems Analysts	506	1,025	520	103%	34	554
Computer Programmers	568	697	129	23%	177	306
Total	1,501	2,634	1,134	75%	244	1,378

All numbers in thousands, except percentages.

SOURCE: U.S. Department of Labor, Bureau of Labor Statistics, 1996 Industry-Occupation Employment Matrix

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Underlying Reasons for Comparatively Slow Growth for Computer Programmers[36]

Compared to the other core IT occupations, computer programming has a slow projected growth rate over the ten-year projection period (23 percent versus more than 100 percent for the other three core IT occupations). Several causes have been cited as underlying factors in this relatively slow growth:

- ***Offshore contracting of code writing.*** Once the higher-level work involved in software development—design, identification of key variables, specification of program modules for manipulation of data, and determination of operation flows and linkages needed to carry out a set of desired tests—has been accomplished, lower-level coding work can be broken into many separate pieces and the work distributed. Increasingly this type of work is being outsourced to low-cost regions of the world, such as Bangalore, India.
- ***Automation of code writing.*** Tools such as CASE (Computer Aided Software Engineering), a collection of automated tools and methods, assist software engineers and reduce the need for programmers by increasing productivity through automation of manual tasks, improving quality through automated checks and reminders, incorporating standardization, and by providing complete and accessible documentation. In effect, this transfers the programmer function to higher-level software engineers.
- ***Advanced programming languages/Object-oriented programming.*** The transition from a mainframe environment to a PC environment blurred the distinction between programmers and users. As pre-packaged software has found its way onto desktops around the country, end-users have become increasingly capable of performing many of the functions that previously resided in the sole domain of programmers.
- ***Demand for "worker bees" down; "queens and kings" up.*** Not all programmers are created equal. In fact, some argue that the best programmers are "not marginally better than good ones, but an order of magnitude better, measured by whatever standard: conceptual creativity, speed, ingenuity of design, or problem-solving ability."[37] The "kings and queens," the gifted professionals in the field, are still in high demand.
- ***"Embedded" programming skills.*** Employers pursuing more bang for their salary buck are seeking employees from other IT or IT-related specialties—such as computer scientists, electrical engineers, and math majors—who also have strong programming skills. While they may not carry the title "programmer," programming is an essential, often core, part of their responsibilities.

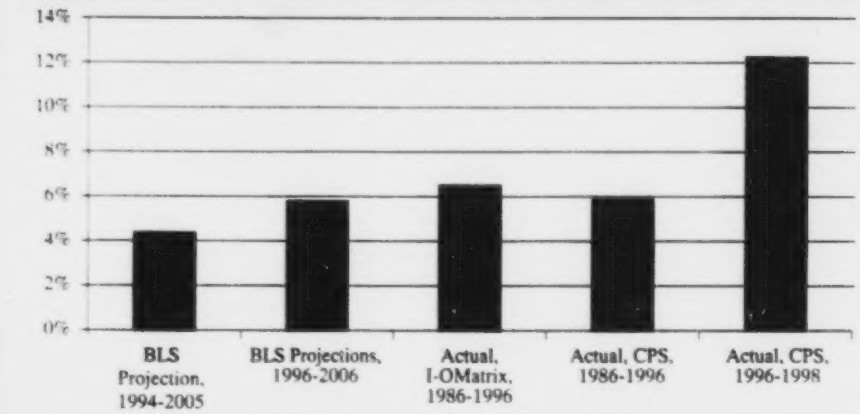
BLS Projections for Core IT Occupations Historically on the Low Side

Nearly all experts agree that the National Industry-Occupation Employment Matrix calculated by the Bureau of Labor Statistics is the best source for employment projections. Some, however, have cast doubt on the reliability of this data suggesting that past BLS projections often have underestimated fast growing occupations. In the IT core occupations, in particular, past BLS projections often have been on the low side, often significantly underestimating their growth. For example, in their 1994 to 2005 projections, BLS projected the number of new core IT workers needed for new jobs and to replace those exiting the profession to average approximately 95,000 a year. In their next round of projections, that average grew to approximately 138,000 a year—an increase of 45 percent, even though the 1996-2006 projections include nine of the years included in the previous projections.

In addition, BLS's projected annual average growth rate for core IT occupations between 1996 and 2006 (5.8 percent) is slightly lower than the actual growth rate in the preceding decade (5.9 percent, according to CPS data, 6.5 percent according to the I-O Matrix), despite the economy's growing reliance on information technology.

There is no data yet from the Occupational Employment Statistics survey or the I-O Matrix to allow for a head-to-head comparison of BLS's projected growth and actual growth in the first two years of the projection. Although Current Population Survey (CPS) data are not directly comparable to OES-based data (for a variety of reasons, including differences in occupational definitions and data collection methods), CPS data show tremendous growth in IT occupations since 1996. According to CPS data, the increase in computer systems analysts and scientists/computer programmers during the first two years of the projection period (an average of 215,000 a year between 1996 and 1998) exceeded the average pace anticipated for the core IT occupations in the 1996-2006 projections (138,000) by more than 50 percent. Viewed in terms of growth rates, CPS data indicate these occupations grew at a substantially higher annual average growth rate (12.3 percent) than BLS projected for core IT workers (5.8 percent) during the 1996-2006 period.

FIGURE 4. Annual Average Job Growth in Core IT Occupations† Actual and Projected



SOURCE: U.S. Department of Labor

† BLS Projections and Industry-Occupation Employment Matrix time series data include computer scientists, computer engineers, systems analysts and computer programmers. Current Population Survey (CPS) data include the occupational categories "Computer Systems Analysts and Scientists" and "Computer Programmers."

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Core IT Occupational Growth Led by the Service Sector

The service sector, in general, and the computer and data processing services (CDPS) industry, in particular, will lead growth in the core IT occupations according to BLS projections.

The service sector[38] is expected to account for the lion's share of growth in the core IT occupations during the 1996-2006 period. By 2006, the service sector is projected to increase its employment of computer systems analysts, scientists, and engineers by 177 percent and computer programmers by 47 percent. In contrast, the manufacturing sector is projected to experience comparatively slower growth in the number of computer scientists, computer engineers and systems analysts (approximately 44 percent), and a 20 percent decrease in the number of computer programmers.

The service sector is expected to account for the lion's share of growth in the core IT occupations during the 1996-2006 period. By 2006, the service sector is projected to increase its employment of computer systems analysts, scientists, and engineers by 177 percent and computer programmers by 47 percent.

CDPS Industry Lead in IT Employment Projected to Grow

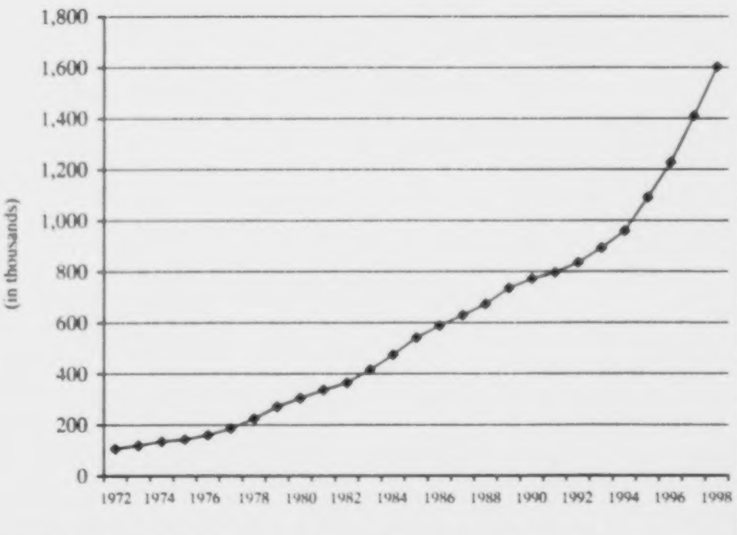
IT occupational growth in the service sector will be led by the CDPS industry, according to BLS projections. CDPS is, by far, the largest employer of core IT workers. [Appendix 1] In 1996, core IT worker employment in the CDPS industry stood at 404,264, or 28.4 percent of all core IT workers; in 2006 the industry employment of core IT workers is projected to grow to 1,036,184, or 39.3 percent of all core IT workers. In all, the CDPS industry is projected to account for 55.8 percent of the total employment growth in IT occupations between 1996 and 2006.

The CDPS industry also has the highest IT worker intensity (defined as core IT workers share of the industry's total work force) of any industry. In 1996, more than one-in-three (33.5 percent) CDPS workers were in the core IT occupations, by 2006 that ratio is projected to grow to more than two-in-five (41.3 percent, projected).

CDPS Industry's Total Employment Projected to Continue Rapid Growth

As of January 1999, Current Employment Statistics data shows the CDPS industry employed more than 1.7 million people, following a quarter century of remarkable employment growth. Between 1986 and 1996, CDPS employment[39] more than doubled, growing from 588,000 to more than 1,228,000. In the preceding decade, employment in the industry grew at a remarkable pace, more than tripling from 160,000 in 1976 to 588,000 in 1986.[40]

FIGURE 5. Computer and Data Processing Services Industry Employment Growth 1972-1998



SOURCE: U.S. Department of Labor, Bureau of Labor Statistics, Current Employment Statistics survey

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BLS projects CDPS employment growth during the 1996-2006 period will lead all other industries, rising from 1.2 million to 2.5 million, an increase of 108 percent. CDPS's average annual growth rate projected during this period—7.6 percent—is almost identical to its average annual growth rate for the preceding decade. However, Current Employment Statistics survey data for the first two years of the projection period (1996 to 1998) show the CDPS industry's employment growing at an average annual rate of 14.3 percent, exceeding even the extraordinary 13.9 percent average annual growth rate of the 1976-1986 period.

In 1996, more than one-in-three (33.5 percent) CDPS workers were in the core IT occupations, by 2006 that ratio is projected to grow to more than two-in-five (41.3 percent, projected).

CDPS Output Also Projected to Continue Rapid Growth

CDPS output is also projected to continue to grow rapidly (9.3 percent annually) during the 1996-2006 period, second only to the computer and office equipment manufacturing industry. This growth rate is in line with the industry's 9.7 percent annual growth rate posted during the 1986-1996 period.[41]

IT Worker Intensity: CDPS Leads All Industries

IT worker intensity—defined as the percentage of an industry's work force composed of core IT occupations—provides a guide to which industries are most reliant on these workers and, by extension, which might be affected most by tight IT labor markets. Table 5 shows the most IT intensive industries both in 1996 and as projected in 2006. Two important facts emerge from this chart. First, the most IT worker intensive industries of 1996 will become increasingly IT worker intensive by 2006. And second, the CDPS industry is, by far, the most IT worker intensive industry and will grow in intensity through 2006. In 1996, one-in-three workers (33.5 percent) in the CDPS industry was a computer scientist, computer engineer, systems analyst, or computer programmer; by 2006, the proportion of core IT workers will rise to two-in-five (41.3 percent).

TABLE 5. Industry IT Worker Intensity†

1996			2006 Projection		
Rank	*Industry*	%	*Rank*	*Industry*	%
1	Computer and data processing services	33.5%	1	Computer and dataprocessing services	41.3%
2	Computer and office equipment	12.4%	2	Computer and office equipment	15.3%
3	Telegraph &communication services, nec	10.0%	3	Telegraph & communication services, nec	13.0%
4	Search and navigation equipment	7.2%	4	Search and navigation equipment	9.2%
5	Communications equipment	6.2%	5	Communications equipment	8.0%
6	Life insurance	6.1%	6	Life insurance	7.7%
7	Medical service and health insurance	6.1%	7	Medical service and health insurance	7.6%
8	Security &commodity exchanges & svces	5.8%	8	Security & commodity exchanges & svces	7.2%
9	Research and testing services	5.3%	9	Banking and closely related functions, nec	6.9%
10	Banking and closely related functions, nec	5.3%	10	Guided missiles, space vehicles, and parts	6.9%
11	Guided missiles, space vehicles, and parts	5.2%	11	Research and testing services	6.5%
12	Management and public relations	4.6%	12	Management and public relations	5.7%
13	Fire, marine and casualty insurance	4.3%	13	Fire, marine and casualty insurance	5.5%
14	Aircraft and parts	4.1%	14	Federal government	5.4%
15	Federal government	3.6%	15	Aircraft and parts	5.4%
16	Engineering and architectural services	3.5%	16	Periodicals	4.7%
17	Periodicals	3.4%	17	Engineering and architectural services	4.5%
18	Electronic components and accessories	3.3%	18	Combination utility services	4.4%
19	Measuring and controlling devices	3.2%	19	Books	4.4%
20	Combination utility services	3.2%	20	Drugs	4.4%
21	Crude petroleum, natural gas, & gas liquids	3.2%	21	Electronic components and accessories	4.3%
22	Drugs	3.1%	22	Crude petroleum, natural gas, & gas liquids	4.3%
23	Federal and business credit institutions	3.1%	23	Measuring and controlling devices	4.2%
24	Holding and other investment offices	3.1%	24	Holding and other investment offices	4.1%
25	Tobacco products	3.0%	25	Tobacco products	4.0%

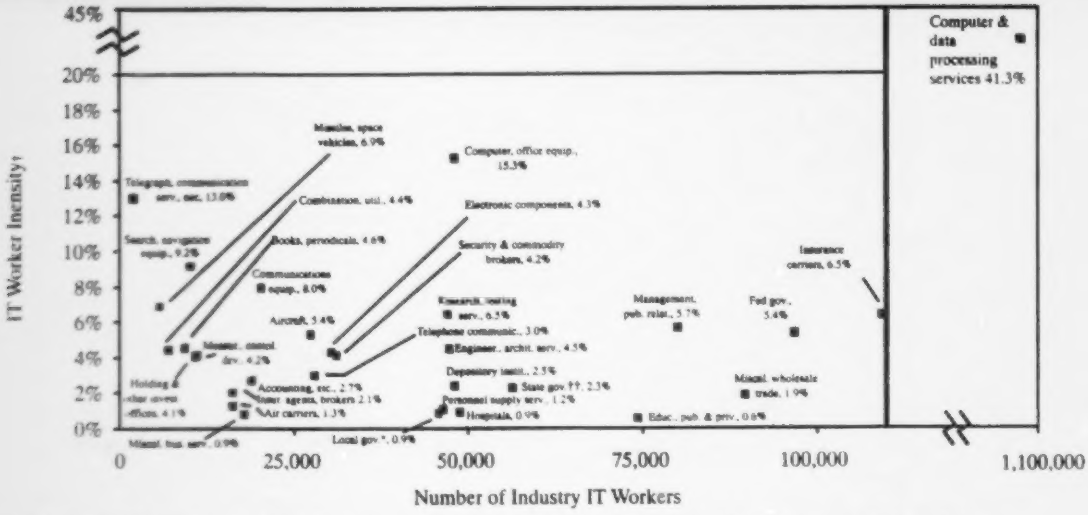
† Percent of industry workers that are computer scientists and engineers, systems analysts, and computer programmers. nec=not elsewhere classified

SOURCE: U.S. Department of Labor, Bureau of Labor Statistics

However, IT worker intensity does not tell the whole story. The size of an industry's IT work force is also an important consideration. For example, while the Federal government is projected to be less IT worker intensive in 2006 than many other industries, the sheer size of its IT work force (96,704, projected) would make tight markets for computer programmers, systems analysts, and computer scientists and engineers a troubling problem. When IT worker intensity and size of the IT work force are taken together, a picture emerges as to which industries' competitive performance would be most adversely affected by difficulties in hiring highly skilled IT workers.

The computer and data processing services industry stands out starkly as an industry with much at stake in the supply of IT workers (see Figure 6). But not only is the CDPS industry affected by the supply of IT workers, the unique characteristics of the industry and its work environment significantly affect the national pool of IT workers from which all industries must draw.

FIGURE 6. Projected IT Worker Intensity & Size of IT WorkForce for Selected Industries in 2006



†"IT worker intensity" is the percentage of a given industry's workers that are computer programmers, system analysts, and computer scientists and engineers.
††State and local government numbers do not include education employees.
SOURCE: U.S. Department of Commerce analysis of U.S. Department of Labor, Bureau of Labor Statistics, 1996-2006 occupations projection.

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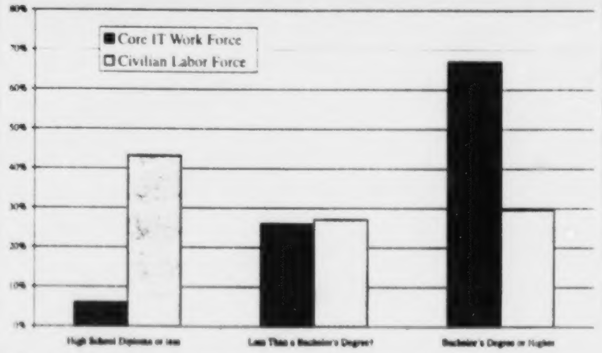
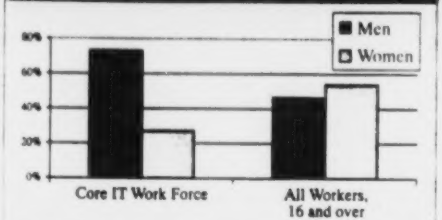
FIGURE 7. Educational Attainment Civilian Labor Force vs. Core IT Work Force



† For CLF, includes "some college, no degree" and "associate's degree;" for Core IT work force, includes "associates degree" and "two-year vocational degree."

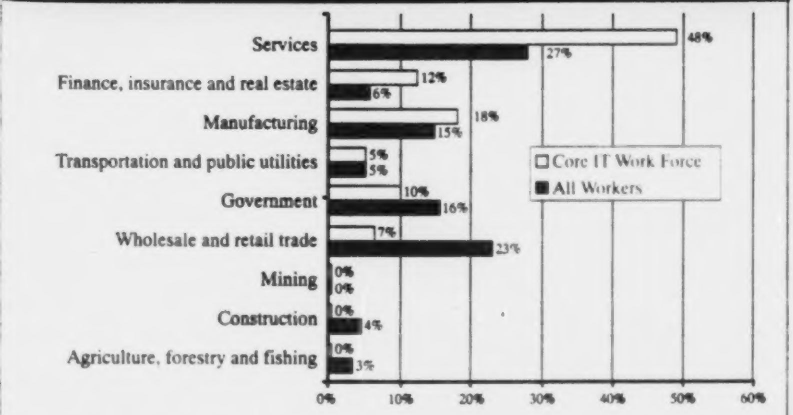
SOURCE: U.S. Department of Commerce analysis of U.S. Department of Labor, Bureau of Labor Statistics, Current Employment Statistics

FIGURE 8. Share of Core IT Work Force, All Workers by Sex in 1998



SOURCE: U.S. Department of Labor, Bureau of Labor Statistics, Current Population Survey

FIGURE 9. Distribution of Core IT Workers, All Workers by Industry Sector in 1996



SOURCE: U.S. Department of Labor, Bureau of Labor Statistics, 1996 Industry-Occupation Employment Matrix

V. THE SUPPLY OF CORE IT WORKERS

Overview

What is the composition of the core IT work force? What are the primary educational and training pipelines that bring people into the core IT occupations? What is the demographic profile of these occupations?

The answers to these questions about the current IT work force provide insights that may improve the infrastructure's ability to produce an adequate supply of appropriately educated and trained workers to meet the demand by identifying:

- who is likely to pursue these career fields in the future,
- where there may be untapped labor pools from which to draw,
- what the educational pathways are to these careers,
- how to better prepare students for these pathways and careers, and
- how to improve the pathways to better prepare students for these careers.

Composition of the Core IT Work Force

The core IT work force has a much different demographic and educational composition than the civilian labor force as a whole. In particular, core IT workers have a much higher level of educational attainment (see Figure 7), a higher proportion of male workers (see Figure 8), and are more likely to be employed in the service sector; the finance, insurance, and real estate industries; and manufacturing (see Figure 9). (Appendix 2, "Distribution of Individual Core IT Occupations by Sector," and Appendix 3, "Core IT Work Force Composition of Primary Sectors by Individual IT Occupation" provide a detailed view of where the core IT work force is employed.)

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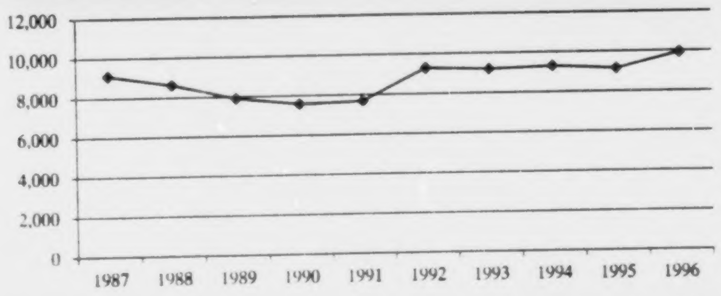
Where Do Core IT Workers Get Their Education and Training?

Most characteristically, core IT workers get their education from four-year colleges; however, there are a wide range of other education and training grounds for IT workers generally, including:

- two-year associate degree-granting community colleges, which provide grounding in applications (especially in new computer programs and hot skill areas) as well as basic theory, and vocational technical education programs. The number of associate degrees awarded in information technology has remained fairly constant (see Figure 10). Between 1987 and 1991, the number of IT associate degrees awarded declined slowly and steadily from 9,101 to 7,574. In 1992 the number jumped 23 percent to 9,290 where it remained steady through 1995. In 1996, the number jumped again, this time by 8 percent to 9,922;
- special university/community college one-year programs designed to upgrade the skills of IT workers already in the work force (new applications) or those with backgrounds in other technical fields who are looking for a fast track entry into the IT profession;
- private-sector computer learning centers, which typically offer courses to people with little or no computer background who are interested in discovering whether they have the aptitude to make it in the computer-related professions;
- in-house company training to upgrade employee skills (e.g. client/server-based tools and architectures, C++ and Visual Basic) or to assist in the transition from one skill set (e.g. computer hardware engineers) to another (e.g. computer software engineers);
- computer user groups, Internet forums, and company-sponsored help sites also offer knowledge that can help expand or update computer skills.

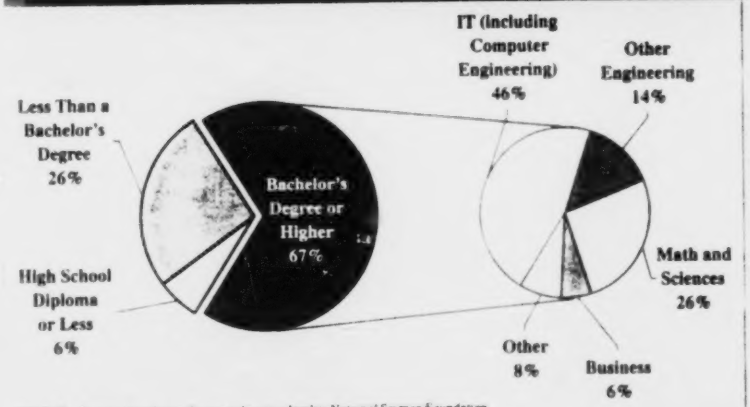
Most jobs in the core IT occupations, however, require a four-year degree or equivalent skills. Data from the Current Population Survey show that two-thirds of the core IT work force are college graduates (with approximately one-in-five holding master's, doctoral, or other graduate degrees), 6 percent have a high school diploma or less, and an additional 26 percent have more than a high school diploma but less than a bachelor's degree (see Figure 11).

FIGURE 10. Associate Degrees in Information Technology 1987-1996



Source: Integrated Postsecondary Education Data System (IPEDS) of the U.S. Department of Education's National Center for Education Statistics

FIGURE 11. Educational Background of Core IT Work Force



SOURCE: Current Population Survey (education levels); National Science Foundation, SESTAT, 1997 data (disciplines of degreed IT workers)

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How Many College Graduates' Education Has Included Preparation for IT Work?

There are approximately one million college graduates whose education has included significant preparation for IT work, most of them holding bachelor's level degrees or higher.[42]

Specifically, the analysis counts approximately 783,700 college graduates in the United States with bachelor's degrees or higher in information technology fields—computer and information sciences or computer engineering—through April 1997. This figure includes graduates with bachelor's degrees in electrical engineering that reported second majors or minors in computer science or related IT specialties. In addition, OTP estimates approximately 105,000 additional college graduates with IT degrees through June 1999.

In addition, as of 1997 there were approximately 119,700 other graduates without IT degrees as such, but who had combined majors in other fields with a minor concentration or second major field of study in an IT discipline. Thus, the total number of college graduates whose education has included preparation for work in the core IT occupations is roughly one million. These numbers are summarized in Table 6, "Persons in the United States with IT-Related College Degrees."

TABLE 6. Persons in the U.S. with IT-Related College Degrees

Group	Number
Persons with an earned IT degree, as of 4-15-97	
• First bachelor's degree in an IT specialty	566,500
• First bachelor's degree NOT in an IT specialty, but recipient of graduate IT degree	217,200
Total degrees as of April 15, 1997	783,700
Estimated subsequent IT degree awards:	
• In 1997	35,000
• In 1998	35,000
• In 1999	35,000
Total subsequent degrees, through 1999	105,000
Total persons with IT degrees at the end of 1999	888,700
Addenda:	
No IT degree, but undergraduate work includes a second major or academic minor in an IT specialty	119,700
Total college graduates whose education has included preparation for work in the core IT occupations	1,008,400

SOURCE: National Science Foundation, SESTAT Data Base, and Richard Ellis

This number is still well short of half the 2 million-plus core IT workers estimated by the 1998 Current Population Survey. In fact, the number of graduates with IT-related degrees working in IT occupations is lower than even these figures suggest, because many graduates with IT or IT-related degrees do not work in the four core IT professions. However, it should be noted that students with degrees in computer and information science are more likely to work in their field of study or a closely related field than any other science and technology discipline (see box, "Computer and Information Science Degree Holders Most Likely to Work in Their Area of Academic Preparation," page 35).

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Computer and Information Science Degree Holders Most Likely to Work in Their Area of Academic Preparation

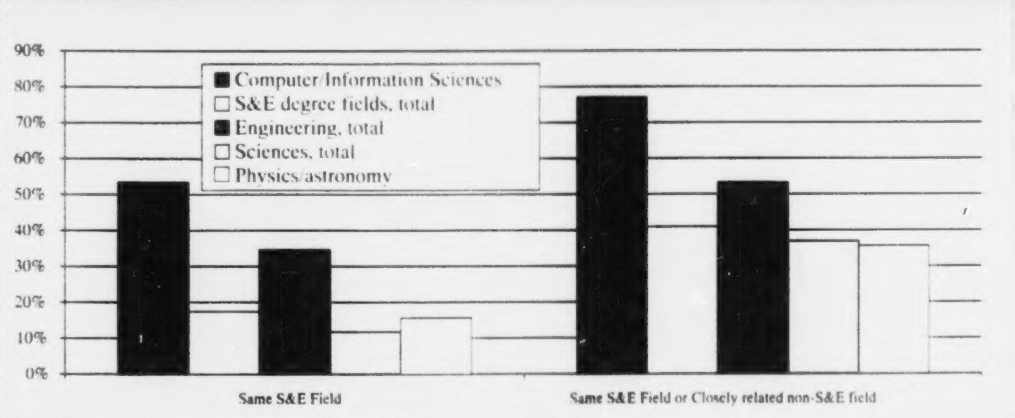
SESTAT data suggests that only about two-thirds of those with bachelor-level or higher IT degrees work in the core IT occupations, with the balance working in non-IT fields (which would include programmers because SESTAT does not include programmers as a core IT occupation). Accordingly, some suggest there is a ready pool of IT-educated workers that could be tapped to meet the growing demand. Some who have earned bachelor's degrees and higher in computer and information sciences work in non-IT occupations.

In fact, though, in every academic discipline there are many who choose to follow occupational paths that diverge from their educational backgrounds for a variety of reasons.

Those with computer and information sciences degrees, however, are the most likely to pursue careers in line with their education.

Figure 12 (below) shows that computer and information sciences degree holders are the most likely of all science and engineering (S & E) degree holders to be employed either strictly in their own S&E field (53.4 percent), or in either their own S&E field or a closely related non-S&E field (77.1 percent). By comparison, only 34.6 percent of those with engineering degrees are employed in their own S&E field, and only 53.3 percent are employed in either their same S&E field or a closely related non-S&E field. For all S&E degree holders, the figures are 17.4 percent and 40.9 percent, respectively.

FIGURE 12. Computer & Information Sciences Degree Holders Most Likely to Stay In-Field for Work

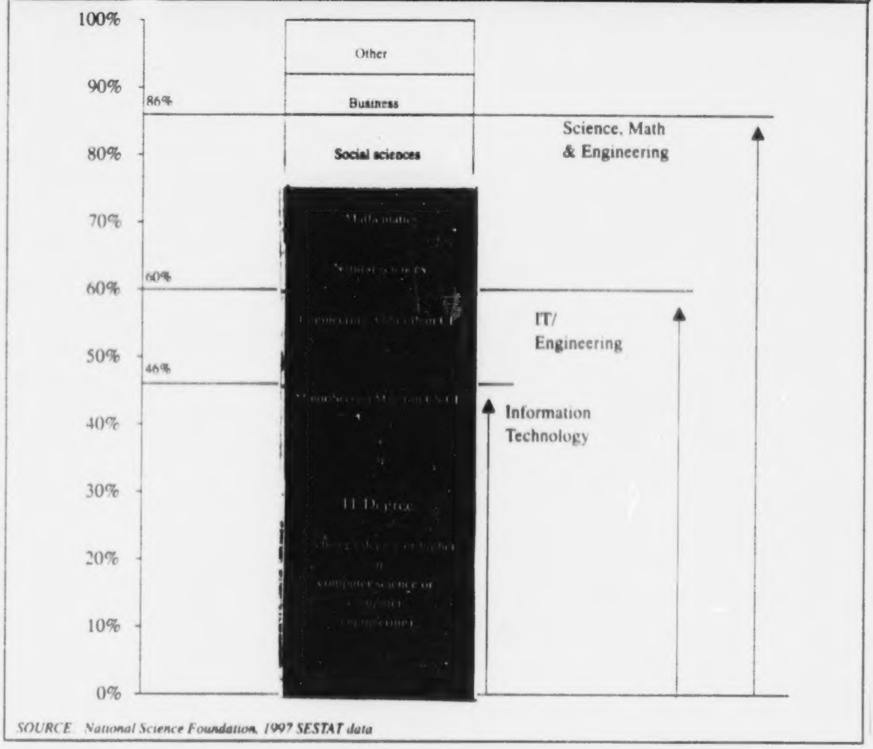


SOURCE: National Science Foundation, 1997 SESTAT data

The National Science Foundation's SESTAT database provides a window into the educational background of core IT workers who have a bachelor's degree or higher.[43] An analysis of the recently released 1997 SESTAT data shows that 42 percent of the core IT work force with degrees has an IT degree (bachelor's or higher degrees in computer science or computer engineering), while another 4 percent completed an undergraduate minor or second major in computer science or computer engineering, for a total of 46 percent (see Figure 13). An additional 40 percent hold a degree in another engineering, science, or mathematics discipline. The remaining degreed IT workers hold degrees in business (6 percent) and other disciplines (8 percent, including those whose first degree is at the master's level or higher).

OTP estimates that approximately one-third (31 percent) of the overall core IT work force has IT degrees, minors or second majors. Still, it is important to note that 86 percent of core IT workers with bachelor-level degrees or higher (58 percent of all core IT workers) hold science and engineering degrees.

FIGURE 13. Educational Background of Core IT Workers



SOURCE: National Science Foundation, 1997 SESTAT data

Science and Engineering Studies are Primary Path to Core IT Occupations

CPS data indicate that two-thirds of core IT workers have bachelor-level or higher degrees. Applying the SESTAT data—which shows that 46 percent of degreed IT workers hold either IT degrees at the bachelor's level or higher, IT minors or second majors—OTP estimates that approximately one-third (31 percent) of the overall core IT work force has IT degrees, minors or second majors. Still, it is important to note that 86 percent of core IT workers with bachelor-level degrees or higher (58 percent

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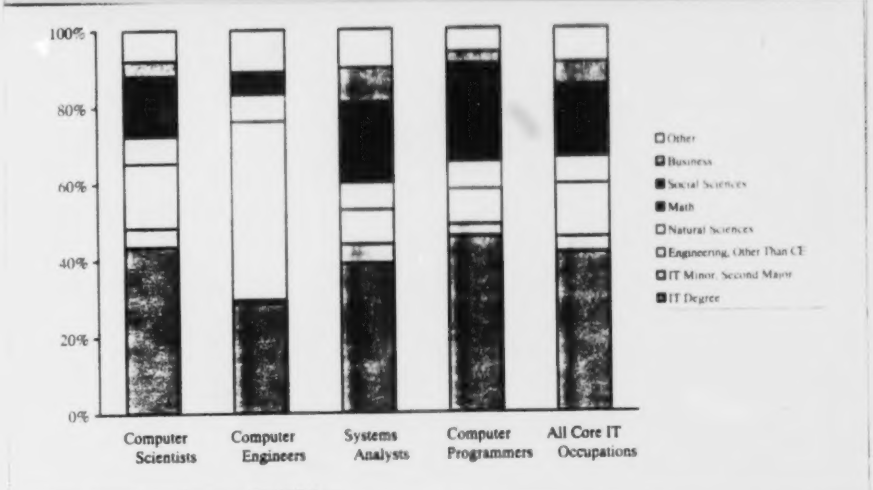
of all core IT workers) hold science and engineering degrees. Clearly, the primary educational pipeline for the core IT work force is through science and engineering curricula, with business studies providing an alternative path.

Figure 14 provides a view of the academic origins of degreed core IT workers for each of the occupations—computer scientists, computer engineers, systems analysts, and computer programmers—as well as for all core IT workers collectively.

FIGURE 14. Academic Origins of Degreed Core IT Workers



SOURCE: National Science Foundation, 1997 SESTAT data

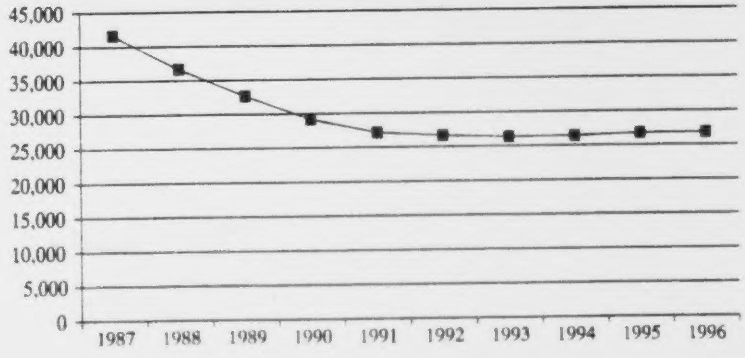
Enrollment and Degree Trends at Four-year Colleges and Universities

America's New Deficit drew attention to the significant decline (more than 40 percent between 1986 and 1994) in bachelor's degrees awarded in computer science. Recent data indicates that the decline has come to a halt, and there has been modest but steady growth in the number of computer and information sciences bachelor's degrees awarded between 1993 and 1996, rising from a ten-year low of 26,338 in 1993 to 26,837 in 1996[44] (see Figure 15). In addition, there is evidence to support the prospect for rapid growth in the number of bachelor's degrees awarded in computer science and computer engineering.

Contrary to the precipitous decline in bachelor's degrees in the late 1980s, the number of associate (Figure 10, see page 33) and master's degrees (see Figure 16, next page) awarded in information technology grew moderately between 1987 and 1996, while the number of doctoral degrees more than doubled (431 in 1987 to 950 in 1996, though the 1996 figure represents a drop from 1,024 in 1995) (see Figure 17, next page).

The number of computer science and computer engineering degrees awarded at the bachelor's level and higher fell from 51,231 in 1987 to 37,951 in 1992. Since then, the number has remained fairly constant, growing slightly to 38,516 in 1996.

FIGURE 15. Bachelor's Degrees in Information Technology, 1987 - 1996



Source: Integrated Postsecondary Education Data System (IPEDS) of the U.S. Department of Education's National Center for Education Statistics

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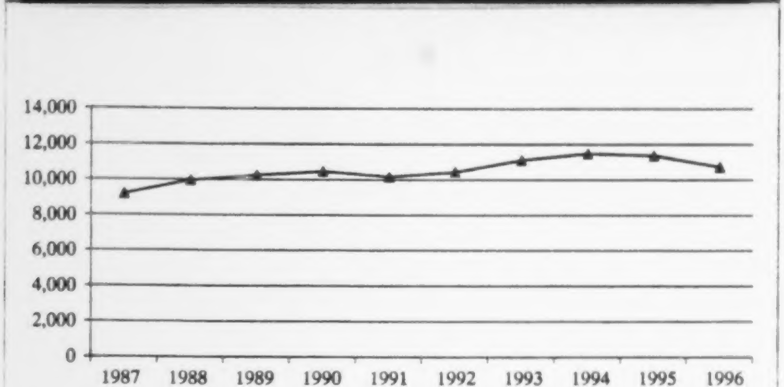
Taulbee Surveys Provide Recent Data on Enrollments and Degrees in Computer Science/Computer Engineering

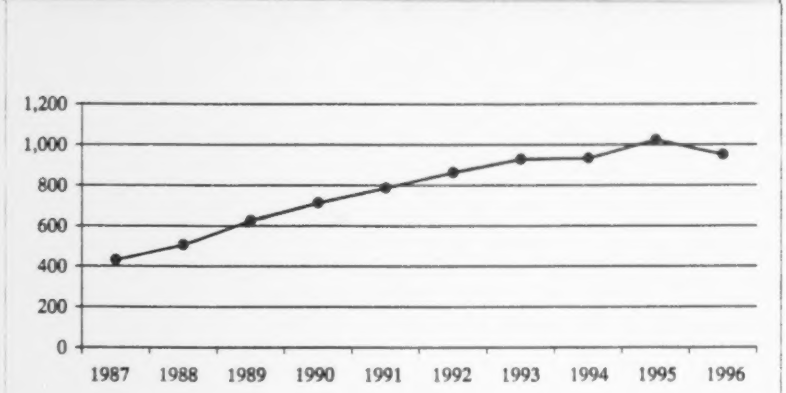
During the past three years, there has been evidence of a strong increase in enrollments in computer science. The most recent Taulbee Surveys[45] provide a positive, though mixed message about the pipeline for four-year degree candidates in computer science and computer engineering.

FIGURE 16. Master's Degrees in Information Technology 1987-1996



Source: Integrated Postsecondary Education Data System (IPEDS) of the U.S. Department of Education's National Center for Education Statistics

FIGURE 17. Doctoral Degrees in Information Technology 1987-1996



Source: Integrated Postsecondary Education Data System (IPEDS) of the U.S. Department of Education's National Center for Education Statistics

Bachelor's Enrollments Up. After years of declining numbers in U.S. computer science degrees, the 1995-96 and 1996-97 Taulbee Surveys showed a sharp upswing in computer science and computer engineering bachelor's enrollments (45.9 percent increase in 1996, 35.3 percent increase in 1997). Taken together, enrollments nearly doubled over this two-year period. It appears, however, that this upswing has leveled off. The preliminary results for the 1997-98 survey show that the increase in bachelor's level enrollments in computer science and computer engineering slowed to 5.4 percent. Still, bachelor's enrollments have risen more than 108 percent during the past three years.

Master's, Ph.D. Enrollments Up As Well. The number of enrollments in Ph.D. programs also rose for the third straight year, posting a 25.3 percent increase in 1998, and up 71.1 percent since 1995. Master's enrollments grew 28.2 percent in 1998, and have increased 106.1 percent since 1995. Taken collectively at all degree levels, enrollments in computer science and computer engineering programs climbed by 10.1 percent in 1998, and a total of 104.4 percent since 1995.

Enrollments in Computer Engineering Skyrocket. Despite a brief retrenchment in 1997, total enrollments (all degree levels) in computer engineering have more than tripled since 1995, rising from 400 in 1995 to 1,358 in 1998. Bachelor's enrollments have led the way, growing by more than 350 percent during this three-year period.

African-Americans, Native Americans Reverse Ph.D. Decline; Hispanics Still Down. While the 1996-1997 Taulbee Survey noted "an alarming drop-off" in the number of Ph.D. degrees awarded to Native Americans (from 5 in 1996 to 0 in 1997), African-Americans (from 11 in 1996 to 6 in 1997), and Hispanics (from 27 in 1996 to 8 in 1997), the 1998 survey shows a reversal in the first two categories (6 Native Americans, 10 African Americans in 1998), but not among Hispanics to whom only 6 Ph.D. degrees were awarded in 1998. Still, the number of Ph.D.s earned by Native Americans, African-Americans, and Hispanics represents only a small fraction of the 1,697 Ph.D.s awarded in computer science or computer engineering in 1998.

Women Enrollments in Ph.D. Programs Continue Steady Rise. For women, the Taulbee Survey shows a steady increase in the number and share enrolled in Ph.D. programs over the past three years, rising from 1,123 (16.2 percent) in 1996 to 1,156 (17.0 percent) in 1997, to 1,340 (18.8 percent) in 1998.

Total enrollments (all degree levels) in computer engineering have more than tripled since 1995.

IT Faculty Growth Projected. The survey also projects a 23 percent growth in faculty over the next five years, an indicator of anticipated enrollment increases.

Enrollment Limitations. Anecdotal evidence indicates that at least some colleges and universities have reached enrollment limits governed by their physical infrastructure and available professors. Additional anecdotal evidence points to an acute difficulty in attracting and retaining information technology educators. This seems especially true for colleges and universities that have small computer science departments and for those in which the computer science department is part of a general arts and sciences program.

One factor in recruiting and retaining qualified professors may be salaries. The Computing Research Association reported in November 1998 that, roughly speaking, the mean 12-month industrial salary for those holding Ph.D. degrees in computer science and computer engineering is about 143 percent of the mean 9-month university salary.[46]

The number of Ph.D.s earned by Native Americans, African-Americans, and Hispanics represents only a small fraction of the 1,697 Ph.D.s awarded in computer science or computer engineering in 1998.

IT-related Certifications, Self-Study and Other Training

Certificate programs have become a key entry point into IT jobs. These programs are attended by a wide range of prospective IT employees, including college graduates with IT degrees interested in developing an expertise in a particular area, college graduates with no IT backgrounds who desire to move into IT jobs, and those with technical aptitude but no college degrees. These programs offer a relatively quick path into IT jobs, though generally at the lower end of the occupations. However, there is considerable debate over whether this type of training provides sufficient foundation for moving into higher-level IT jobs and for transitioning into new technical areas necessitated by the rapid advance of information technologies.

Though there is no government data on certifications awarded through these programs, there is much anecdotal evidence indicating that there has been rapid growth over the last decade.

One example is the popularity of Microsoft certifications. At the Pacific Northwest town meeting, a Microsoft executive gave several key data points:

- Microsoft has experienced an explosion in the number of people being trained around its technology. "About five years ago we were training 30,000 technical professionals a year and this year we'll train 1.2 million in commercial classrooms through 1,900 independent companies around the world."
- Approximately 4.1 million will buy and use a self-study book or CD-ROM training title.
- On-line learning is the fastest growing method individuals are using to get Microsoft training. An estimated 10 million people will participate in a free on-line seminar.
- In the past four years, more than 250,000 people have earned Microsoft Certified Professional credentials.

Beyond its relationship with 1,900 commercial training companies, Microsoft is working with 1,000 academic institutions around the world to achieve this extensive training capacity. While approximately 900 of these academic institutions are located in the United States, Microsoft expects that the fastest growth in education partnerships in 1999 will be outside the United States. Of the 900 U.S. schools, about a third are high schools (the fastest growing segment), half are community colleges, and the balance are four-year colleges.

Profile of Microsoft Certified Professionals

Sex:	89% male; 11% female
Education:	31% have some community college education 43% are college graduates 24% have some graduate education
Location:	50% are outside the United States
Ages:	7% are 18-24 years old 50% are 25-34 32% are 35-44

SOURCE: The North Dakota Information Technology Summit, University of Mary, October 27-28, 1998 citing a survey of 360,000 Microsoft Certified Professionals

VI. INDICATIONS OF A TIGHT LABOR MARKET

Overview

Generally, experts suggest that the combination of fast employment growth, rising compensation and low unemployment rates may signal a tight labor market.

Fast Employment Growth

In Chapter 3, "Demand for Core IT Workers," this report documents the extraordinary growth of the core IT occupations and IT-related industries over the past decade, and lays out a case for strong continued growth. The factors expected to keep this demand strong well into the future are presented in Chapter 2, "The Vital Role of IT in the U.S. Economy."

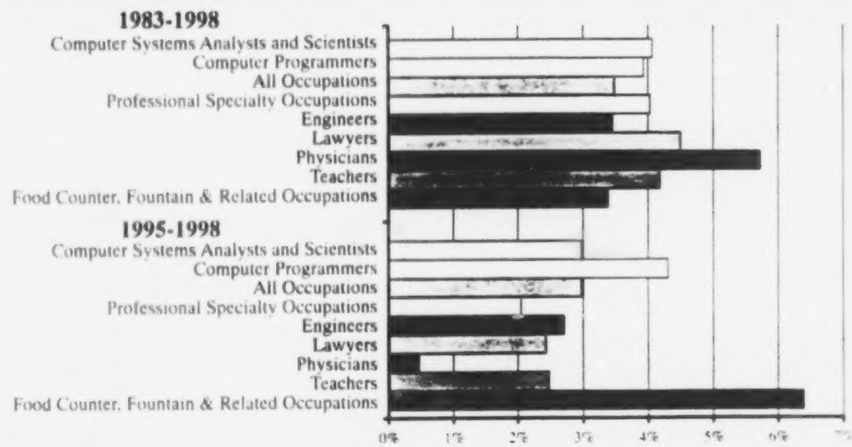
Compensation

In contrast to the strong quantitative data showing the rapid growth of the core IT occupations, evidence of strong rising compensation for these occupations is mixed.

While it seems clear, from both government and non-government data, that the compensation level for IT professionals is both high and rising, the question remains whether rising compensation is unique to these occupations and the result of a tight labor market, or whether it is part of a more general trend generated by a very prosperous U.S. economy.

Indicators are mixed on this point. Government wage data (from the Current Population Survey) shows moderate growth in recent years, in line with overall wage growth, in the range of 3-4 percent a year. In contrast, several private wage surveys show a faster pace of wage growth for IT occupations generally, in the range of 7-9 percent per year, while those in particularly hot specialties are seeing double-digit salary increases and premium pay above base salary for hot skills.

FIGURE 18. Average Annual Salary Increase for IT and Other Selected Occupations



SOURCE: U.S. Department of Labor, Bureau of Labor Statistics, Current Population Survey, 1983-1998 Annual Average
NOTE: Minimum wage increase from $4.25 hour to $4.75 hour on October 1, 1996, and to $5.15 hour in September 1997

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Government experts suggest that the variance between the government and private wage surveys is generally the result of various factors including sample size and survey methodology (design of samples, use of well-constructed and tested questions, methods of obtaining higher rates of sample responses), concluding that the government data is likely to be significantly more accurate.

Though there are mixed signals on compensation for the core IT occupations generally, analysis by the Commerce Department's Office of Technology Policy indicates a consensus in several areas:

- IT worker salaries are high and rising.
- Those with hot skills are seeing fast rising salaries and are commanding a salary premium above those whose skills are less hot, more dated or more generic.
- Those with combinations of multiple hot skills and relevant industry experience are seeing especially fast rising compensation.
- Starting salaries are rising fast.

Support for these findings are provided in the following sections.

Government Data

The best government source for salary data on the core IT occupations that is both current and longitudinal is the Current Population Survey conducted by the U.S. Department of Labor's Bureau of Labor Statistics and the U.S. Department of Commerce's Bureau of the Census.

Figure 18 (previous page) provides a comparative framework for examining salary increases for the core IT occupations. This chart provides the annual average salary increase for several key, representative occupations and occupational groupings using a 15-year horizon to show long-term trends, and a three-year horizon to examine more recent trends.

The occupational categories used in this comparison were chosen for specific reasons: "all occupations" provides the broadest benchmark; "professional specialty occupations" provides a broad standard for professionals generally; "engineers" provides a comparison to another core technology occupation; "lawyers" and "physicians" were included because of their reputation for high, fast-rising salaries; teachers are another fast-growing professional occupation; and "food counter, fountain and related occupations" provides a comparison to low-wage occupations that have enjoyed strong salary growth in recent years.

Over the 15-year horizon, the average annual salary increase for the core IT occupations (computer systems analysts and scientists; computer programmers) was approximately four percent, slightly higher than for the overall work force, engineers and food counter workers, and on par with professional specialty occupations and teachers. In contrast, lawyers (4.5 percent) and physicians (5.7 percent) especially, outpaced IT workers during this time frame.

During the 1995-1998 time frame, however, things look different. Food counter workers have benefited from a 6.4 percent average annual salary increase, driven in part by an increase in the minimum wage from $4.25 per hour to $5.15 per hour during this time period.[47] The increase in the minimum wage also contributed to the overall work force's 3.0 percent average annual salary increase. Computer systems analysts' and scientists' salary increase during this period was equal to that of the overall work force, but higher than professional specialty occupations as a whole, and lawyers, physicians, and teachers in particular. Computer programmers enjoyed an even greater increase in salary during this period, posting an average annual salary increase of 4.3 percent, despite the fact that demand for computer programmers has been, and is projected to be, much slower than for other core IT occupations. However, the higher average annual salary increases for computer programmers are supportive of the Office of Technology Policy's conclusion that skills in the hot programming areas are in high demand and being rewarded accordingly.

Skills in the hot programming areas are in high demand and being rewarded accordingly.

1997 National Occupational Employment and Wage Estimates.[48] OES data does not allow for an analysis of wage trends because the OES survey only began collecting wage data in 1996. However, the information from OES provides a good snapshot of employment and wages for the core IT occupations (see Table 7; note that the category "Engineering, Mathematical, and Natural Science Managers" in Table 7 includes some computer systems managers).

Private Salary Surveys

Compared to the government data, private sector salary surveys generally suggest faster salary increases for core IT workers of 7-9 percent in recent years, and even more rapid increases for those working in key specialties and/or those with hot skills or combinations of hot skills.

This section summarizes the findings of several key salary surveys.

TABLE 7. Mean Wages for Computer-related Occupations

Occupation Title	Mean Wage	
	Hourly	Annual
Engineering, Mathematical, and Natural Sciences Managers	$32.99	$68,620
Computer Engineers	$27.21	$56,590
Systems Analysts, Electronic Data Processing	$24.69	$51,360
Computer Programmers	$24.27	$50,490
Database Administrators	$23.06	$47,960
Computer Support Specialists	$18.71	$38,920
All Other Computer Scientists	$22.87	$47,570

SOURCE: U.S. Department of Labor, Bureau of Labor Statistics, Occupational Employment Survey

The Institute of Electrical and Electronics Engineers-USA (IEEE-USA) 1999 Salary and Fringe Benefits Survey.[49] IEEE-USA reports in its 1999 Salary and Fringe Benefits Survey that the purchasing power of its members has reached an all-time high, surpassing the previous high recorded in its previous biennial survey. In particular, IEEE-USA's 1999 Salary and Fringe Benefits Survey finds that the primary income—base salaries, net earnings from self-employment, and commissions and bonuses—of IEEE members working full-time in their areas of professional competence rose 13.9 percent to $82,000 between 1997 and 1999, compared to a 3.3 percent increase in the Consumer Price Index in urban areas for the same period. When income from all

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sources—second jobs, payments for overtime, pension benefits, and the like—is considered, the increase rises to 14.7 percent during this period, pushing the median wage to $87,200. Engineers working outside their primary area of competence also did very well, especially full-time, self-employed engineers who registered a 19.4 percent increase in income from primary sources.

***Information Week* 1999 National IT Salary Survey.**[50] *Information Week*'s 1999 National IT Salary Survey reports a median annual salary increase of 8.9 percent for all IT workers—9.2 percent for managers, 8 percent for staff. Year 2000 work is worth the most for managers (median salary: $88,000), followed by data mining ($80,000); for staff, it is enterprise resource planning work and data mining ($62,000). Security—including firewall, intrusion detection, public-key infrastructure, and encryption technologies—is another hot skill area. *Information Week* reports that the next move for ambitious IT workers, according to recruiters, is combining hot skills.

Computerworld *surveys conducted six months apart seemed to show very different results.*

"The joyride is over," September 1998

"No Cure in Sight," March 1999

***Computerworld*—12th Annual Salary Survey/1999 Midyear Salary Survey/5th Annual Skills Survey**. *Computerworld* surveys conducted six months apart seemed to show very different results. In September 1998, under the banner "Enough is Enough," *Computerworld* proclaimed the end of rapid salary increases for IT workers based on their 12th Annual Salary Survey:

> "The joyride is over, as corporate managers put the brakes on out-of-control salaries for IT professionals.…Several information systems organizations continue to bloat salaries as a means of retaining and recruiting employees. But after years of raising wages to market rates and beyond, many managers are cutting back on base pay increases and looking for salvation in innovative bonus programs and noncash incentives. In fact, the typical increase in IS salaries from 1997 to 1998 was between 3% and 5%, according to *Computerworld*'s 12th Annual Salary Survey, conducted in June. That increase is in line with most occupations and considerably lower than the previous year's 11% average."

Six months later, in March 1999, the publication took a different position based on its 1999 Midyear Salary Survey under the header "No Cure in Sight:"

> "Last year's shortage of top technology talent was enough to make many hiring managers queasy. Will the fever finally subside in 1999? If 1998 was a great year to be in IT, 1999 looks to be more of the same: rising salaries, personnel shortages that spell tremendous opportunity and signing bonuses for those who are most in demand. Salaries have risen so sharply in the past year and a half that information technology managers are struggling to keep up with market rates—or to even know what they are."

In its Fifth Annual Skills Survey (November 1998)[51] of 493 IT hiring managers, *Computerworld* reported on the hot skills and the salary premiums paid for these skills to permanent employees above their annual salary and to contractors above their normal compensation rate.

For permanent employees, Gupta SQL Base is the hottest skill, paying a 29 percent premium, followed by Centura (Gupta) SQL Windows (20 percent), Baan (20 percent), SAP (17 percent), and Oracle (17 percent).

For contractors, the development tool Progress is the hottest skill, commanding a premium of 35 percent, followed by Centura (Gupta) SQL Windows (33 percent), Novell Group Wise (29 percent), Dunn and Bradstreet's GEAC (29 percent), J.D. Edwards (26 percent), and data warehousing/data mining (26 percent).

Table 8 shows IT hiring managers' projected top skill areas for 1999 according to *Computerworld*'s Fifth Annual Skills Survey as reported in November 1998.

Datamasters 1999 Computer Industry Salary Survey.[52] Datamasters' Computer Industry Salary Survey provides national and regional salary data on a wide range of IT management and professional specialties. Tables 9 and 10 show the range (among the regions) of salary increases for the hottest management professional specialties. The only specialty group in either management or professional staff, in any region, to receive more than a 10 percent increase in salary was Senior Systems Administrator-UNIX in the Southeast region.

TABLE 8. Computerworld's Projected Hot Skill Areas in 1999

Internet Skills	Net development tools, HTML, Java
Languages	Cobol, C++, C
Development Tools	Visual Basic, Oracle Developer 2000, Visual C++
Networking	TCP/IP, SNA, IPX
DBMS/RDMS	Oracle, Microsoft SQL Server, DB2
Operating Systems	Windows NT, Windows 95, Unix
Internetworking	10Base-T switching, ethernet switching, routing
LAN Administration	Microsoft NT Server, Novell NetWare, Ethernet
Office/Email/Groupware	Microsof. Exchange, Lotus Notes, CC: Mail
Client Server Applications	Oracle, Peoplesoft, SAP
System Software & Support	Y2K conversion, help desk, data warehousing/data mining

SOURCE: Computerworld, November 1998

Systems Administration, Networking and Security (SANS) Institute Fifth Annual Salary Survey.[53] The Fifth Annual Salary Survey of the Systems Networking and Security Institute reports rapidly growing salaries for system, network and security administrators. The average reported raise was 11.9 percent. System administrators reported raises of 11.9 percent; network administrators, 12.1 percent; security administrators, 11.7 percent. Independent consultants report salaries $22,000 higher than their contractor counterparts who, in turn, report salaries $10,000 higher than salaried employees.

1998 *Network World* Salary Survey.[54] The 1998 *Network World* Salary Survey reports total compensation for network professionals in 1998 increased by 10.1 percent over 1997 compensation. In addition, the survey shows that bonuses, stock and overtime typically account for 12 percent of total compensation, though for the most highly paid IT professionals it can account for up to 30 percent. Those surveyed indicated an expected increase in compensation of 6.5 percent for all network professionals, and 7 percent for senior IT managers in 1999; predictions in the 1996 and 1997 *Network World* Salary Survey proved to be on the low side.

TABLE 9. Hottest Management Specialties†

Specialty	Region Range
Database Administrator Manager	8.6-8.8%
Network Manager LAN/WAN	8.1-8.5%
AS 4000 Manager	8.0-8.4%

TABLE 10. Hottest Professional Staff Specialties†

Specialty	Region Range
Year 2000 Analyst	8.4-10.0%
Quality Assurance Analyst	8.0- 8.3%
Sr. Systems Administrator-UNIX	7.7-17.7%††

† as measured by increases in salary
†† With the exception of the Southeast Region, which recorded a 17.7 percent increase, the regional average salary increases for Sr. Systems Administrator-UNIX were in the 7.7-8.2 percent range.
Source: U.S. Department of Commerce analysis of Datamaster data

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Starting Salaries

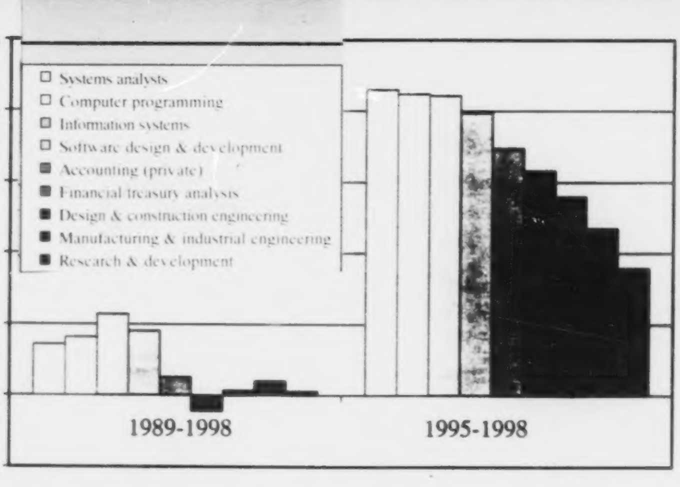
The National Association of Colleges and Employers. New entrants into the core IT occupations have benefited from high increases in starting salary offers during the past three years, according to the National Association of Colleges and Employers (NACE, formerly the College Placement Council, Inc.). NACE has collected data for many years on starting salary offers for bachelor's degree holders across a wide range of occupations, including three of the core IT occupations—computer scientists, computer engineers, and computer programmers. Reporting on NACE's most recent data, CNNfn proclaimed in a headline, "*Hot jobs for tomorrow's grad: Computer-related degrees will rule, thousands of other grads will be left out,*" stating in the article, "The most heavily recruited grads this year hold degrees in engineering, software design and development, computer programming and information systems."

Hot jobs for tomorrow's grad: Computer-related degrees will rule.

NACE data provide a window into the long and short-term behavior of starting salary offers. OTP analyzed starting salary offers for the IT professions and several other professional specialties—accounting (private), financial/treasury analysis, design and construction engineering, manufacturing and industrial engineering, and research and development—to identify longer term and more recent trends (see Figure 19).

Each of the occupations studied recorded declines in real starting salary offers (in the range of 5-10 percent) between 1989 and 1994. As a result, average annual salary increases for these occupations were low during the 1989-1998 period (1.2 percent and below, with financial/treasury analysts recording a real decrease). Still, each of the core IT occupations logged higher average annual starting salary offer increases than the other professions.

FIGURE 19. Real Growth in Starting Salary Offers for Core IT Workers Outpaces Other Occupations (Real Annual Average Starting Salary Increases)



Source: National Association of Colleges & Employers, May 1999.

More recently, the picture is brighter for everyone, especially IT workers. Once again each of the IT occupations outpaced the other occupations in average annual salary increases, logging increases of 4.0 to 4.3 percent during the 1995-1998 period, compared to increases of 1.8 to 3.5 percent for the other occupations. Overall, real starting salary offers (adjusted for inflation) for the IT occupations increased between 13-17 percent from 1995-1998, compared to 5-11 percent for the other occupations.[55]

Thus, compared to other professions, IT workers have enjoyed faster growth in average annual starting salary offers during both the short and longer term.

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RHI Consulting 1999 Salary Guide and Surveys.[56] RHI Consulting projects a 7.3 percent average increase in starting salaries for IT professionals overall in 1999, and even faster salary growth for the hot specialties (see Table 11). In addition, particularly strong IT hiring activity is projected in 1999 for the finance, insurance and real estate industry as well as the business and professional services industry.

Unemployment

The third criterion pointing to a tight IT labor market is low unemployment rates in the core IT occupations. Recent low unemployment rates for these occupations make a compelling case for a tight IT labor market. According to data from the Current Population Survey, while core IT workers have long enjoyed a low unemployment rate, the rate has fallen from 3.0 percent in 1991 to just 1.4 percent in 1998 (see Figure 20).

CPS data also shows that between 1987 and 1998 the unemployment rate for core IT workers hovered around 2.0 percent, except for a three-year period in the early 1990s when it rose to its recent high of 3.0 percent before starting its decline to record lows of between 1.3 and 1.4 percent for the past three years. In 1998, the unemployment rate for computer scientists, computer engineers and systems analysts was 1.3 percent, while computer programmers recorded an unemployment rate of 1.4 percent.

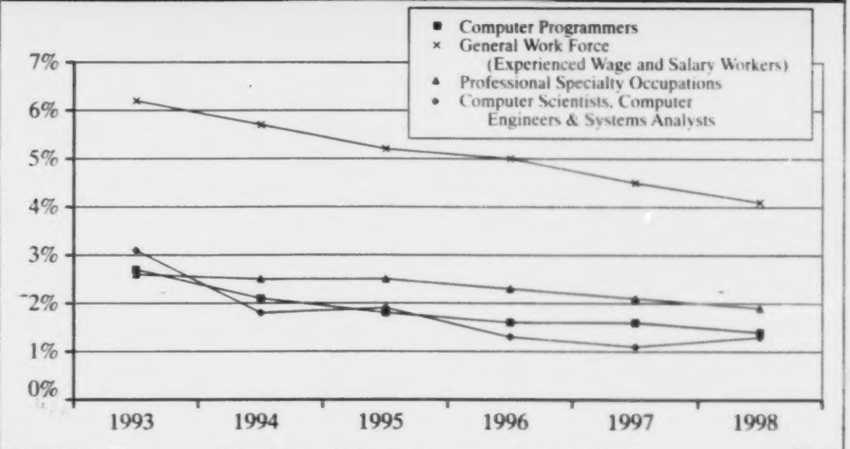
Compared to other professions, IT workers have enjoyed faster growth in average annual starting salary offers during both the short and longer term.

TABLE 11. Projected Starting Salaries and 1999 Increases for IT Occupations

Occupation	Increase	Annual Salary Range
Programmers (C, C++, Visual Basic)	18.40%	$38,000 to $50,500
Database Administrators	16.30%	$61,250 to $88,000
Webmasters	14.70%	$51,500 to $73,000
Software Package Implementation Specialists	13.50%	$56,250 to $80,000
Software Engineer	12.50%	$55,000 to $80,000
Electronic Commerce (eCommerce) Specialists	12.40%	$45,000 to $73,000
Project Managers	10.00%	$60,000 to $80,750
Software developers with installation and development expertise	9.50%	$50,000 to $65,000
Network Administrators	7.90%	$42,750 to $59,750
Chief Information Officers	4.40%	$113,500 to $180,000
Help Desk Managers	3.40%	$67,500 to $85,500

Source: RHI Consulting, 1999 Salary Guide

FIGURE 20. Unemployment Rates for IT Workers are Low Compared to the General Work Force and Professional Specialty Occupations



SOURCE: U.S. Department of Labor, Bureau of Labor Statistics, Current Population Survey

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In contrast, the national unemployment rate—which reached a 42 year low of 4.2 percent in March 1999—is still three times as high as the unemployment rate of the core IT occupations. And core IT unemployment rates are low even compared to other professional occupations. The unemployment rate for IT workers fell below that of the "professional specialty occupations" as a whole in 1994 and remains there today.

VII. STATE AND REGIONAL PERSPECTIVES

Job Growth

Every two years, each state employment security agency does employment projections for its state using national data generated by the Bureau of Labor Statistics' biennial employment projections. The Department of Commerce's Office of Technology Policy has analyzed these state projections. The results are displayed in Tables 12 and 13, and Appendix 4. The highlights are summarized below.

Table 12, "State Leaders in Core IT Occupations," shows the states ranked in each of four categories: number of core IT employees in 2006, percent increase in core IT workers from 1996 to 2006, average annual openings in core IT occupations (including both new jobs and net replacements), and by state IT intensity (defined as core IT workers' share of total employment in the state). Key findings include:

- The two states with the largest populations, California and Texas, are projected to have the largest number of core IT workers in 2006; Virginia, with a comparatively small population, ranks third. These three states also lead the country in the average annual number of core IT job openings between 1996 and 2006.
- Oregon, Georgia and Colorado top the list of states with the fastest growing cadre of core IT workers between 1996 and 2006; Oregon is projected to triple its core IT work force, while Georgia and Colorado are projected to double in size.
- Virginia (3.7 percent), Massachusetts (2.6 percent) and Colorado (2.6 percent) are projected to have the highest state IT worker intensity in 2006; the national IT worker intensity in 2006 is projected to be 1.7 percent.

Table 13, "State Rankings," provides a state-by-state listing with ordinal rankings in the four categories shown in Table 12. Only four states are among the top ten in each of the four ranking categories: Virginia, California, Massachusetts, and Georgia.

Appendix 4, "State Projections for Core IT Occupations," provides each state's current and projected employment in each of the four occupations that comprise the core IT work force.

Regional Compensation Data

National Compensation Surveys, Bureau of Labor Statistics

Data from the Bureau of Labor Statistics' new National Compensation Surveys (Table 14) indicate substantial regional variations in the IT labor markets. For each occupation there are substantial differences in the average salaries in different regions, and there are also substantial differences in the relative salaries of the different occupations in the regions. For example, in Detroit, computer programmers earn more than computer systems analysts/engineers, whereas in Charlotte, North Carolina, computer systems analysts/engineers earn 50 percent more than computer programmers. It is unclear from the data whether the differences reflect different

TABLE 12. State Leaders in Core IT Occupations

Largest Number by Number Employed in 2006		**Fastest Growing** by Percent Increase, 1996-2006		**Largest Number of Job Openings** by Average Annual Openings, 1996-2006		**Highest Intensity** by Core IT Workers' Share of Total Employment, 2006	
California	295,700	Oregon	218	California	16,520	Virginia	3.7%
Texas	167,500	Georgia	112	Texas	7,920	Massachusetts	2.6%
Virginia	135,100	Colorado	101	Virginia	7,670	Colorado	2.6%
Illinois	125,000	Virginia	98	Illinois	6,460	New Jersey	2.5%
New Jersey	105,900	Minnesota	92	Georgia	5,560	Washington	2.3%
Massachusetts	96,400	Arizona	83	New Jersey	5,300	Connecticut	2.2%
Florida	95,450	North Carolina	80	Massachusetts	5,060	Minnesota	2.2%
Ohio	93,950	Nevada	80	Ohio	4,730	California	1.9%
Georgia	90,750	Massachusetts	79	Florida	4,620	Georgia	1.8%
Washington	79,750	California	78	Colorado	4,160	Oregon	1.8%
Colorado	71,050	South Dakota	76	Washington	4,040	Illinois	1.8%
North Carolina	69,950	Washington	76	North Carolina	3,770	New Hampshire	1.7%
Minnesota	66,250	Idaho	75	Minnesota	3,700	Rhode Island	1.7%
Connecticut	41,800	Rhode Island	75	Arizona	2,180	Utah	1.6%
Missouri	40,250	Illinois	72	Wisconsin	1,920	Texas	1.5%
Arizona	39,650	New Hampshire	72	Missouri	1,890	North Carolina	1.5%
Wisconsin	38,600	Ohio	70	Connecticut	1,880	Ohio	1.5%
Oregon	32,100	Wisconsin	66	Alabama	1,730	Delaware	1.4%
Alabama	31,000	New Jersey	65	Tennessee	1,310	Arizona	1.4%
Tennessee	27,550	Alabama	64	Oregon	1,300	Alabama	1.3%
Utah	24,050	New Mexico	64	Utah	1,190	Missouri	1.3%
Oklahoma	18,600	West Virginia	64	Oklahoma	870	South Dakota	1.3%
South Carolina	16,250	Florida	63	South Carolina	770	Nebraska	1.3%
Louisiana	16,100	Utah	62	Louisiana	760	Wisconsin	1.2%
Kentucky	13,800	North Dakota	62	Kentucky	680	New Mexico	1.2%
Nebraska	13,750	Texas	61	New Hampshire	610	Vermont	1.2%
New Hampshire	11,700	Louisiana	59	New Mexico	510	Idaho	1.2%
New Mexico	10,500	Tennessee	59	Nebraska	480	Florida	1.1%
Rhode Island	9,250	Hawaii	59	Rhode Island	470	Oklahoma	1.1%
Arkansas	8,500	Kentucky	58	Nevada	430	North Dakota	1.0%
Idaho	8,150	South Carolina	56	Idaho	410	Maine	1.0%
Nevada	7,950	Oklahoma	55	Arkansas	400	Hawaii	0.9%
Mississippi	7,350	Maine	55	Mississippi	330	Tennessee	0.8%
Delaware	6,550	Arkansas	55	South Dakota	320	South Carolina	0.8%
Maine	6,500	Mississippi	54	Maine	300	Alaska	0.8%
South Dakota	6,050	Missouri	53	West Virginia	300	Louisiana	0.7%
West Virginia	6,050	Connecticut	51	Hawaii	260	West Virginia	0.7%
Hawaii	5,350	Vermont	45	Delaware	250	Kentucky	0.7%
Vermont	4,250	Alaska	43	North Dakota	190	Arkansas	0.6%
North Dakota	4,150	Delaware	36	Vermont	180	Nevada	0.6%
Alaska	2,600	Nebraska	29	Alaska	120	Mississippi	0.6%
Montana	2,500	Wyoming	24	Montana	80	Wyoming	0.4%
Wyoming	1,050	Montana	20	Wyoming	40	Montana	0.4%

Projections not available at time of publication for the District of Columbia, Indiana, Iowa, Kansas, Maryland, Michigan, New York and Pennsylvania.

SOURCE: U.S. Department of Commerce, Office of Technology Policy analysis of data provided by state employment security agencies.

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TABLE 13. State Projections Rankings†

State	Number Employed in 2006	Percent Increase 1996-2006	Average Annual Openings	IT Worker Intensity
Alabama	19	20	18	20
Alaska	41	39	41	35
Arizona	16	6	14	19
Arkansas	30	34	32	39
California	1	10	1	8
Colorado	11	3	10	3
Connecticut	14	37	17	6
Delaware	34	40	38	18
Florida	7	23	9	28
Georgia	9	2	5	9
Hawaii	38	29	37	32
Idaho	31	13	31	27
Illinois	4	15	4	11
Kentucky	25	30	25	38
Louisiana	24	27	24	36
Maine	35	33	35	31
Massachusetts	6	9	7	2
Minnesota	13	5	13	7
Mississippi	33	35	33	41
Missouri	15	36	16	21
Montana	42	43	42	43
Nebraska	26	41	28	23
Nevada	32	8	30	40
New Jersey	5	19	6	4
New Mexico	28	21	27	25
North Carolina	12	7	12	16
North Dakota	40	25	39	30
Ohio	8	17	8	17
Oklahoma	22	32	22	29
Oregon	18	1	20	10
Rhode Island	29	14	29	13
South Carolina	23	31	23	34
South Dakota	36	11	34	22
Tennessee	20	28	19	33
Texas	2	26	2	15
Utah	21	24	21	14
Vermont	39	38	40	26
Virginia	3	4	3	1
Washington	10	12	11	5
West Virginia	37	22	36	37

†Ordinal ranking among the 43 states that have prepared employment projections; projections not available at time of publication for the District of Columbia, Indiana, Iowa, Kansas, Maryland, Michigan, New York and Pennsylvania.

SOURCE: U.S. Department of Commerce, Office of Technology Policy analysis of data provided by state employment security agencies.

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TABLE 14. Annual Earnings for Selected Occupations, Full-time Workers Only, All Industries

Region	Month and Year	Computer systems analysts and scientists	Computer programmers	Electrical and electronic engineers
Atlanta	Oct-97	$51,002	$46,966	$60,590
Charlotte-Gastonia-Rock Hill, NC-SC	Jun-98	58,198	37,732	68,245
Cleveland - Akron, OH	Feb-98	55,578	41,101	57,013
Columbus, OH	Mar-98	46,929	Not available	52,208
Denver-Boulder-Greeley, CO	May-98	58,718	56,326	61,048
Detroit - Ann Arbor - Flint, MI	Mar-98	52,416	59,051	Not available
Houston-Galveston-Brazoria, TX	Oct-97	54,392	37,710	Not available
Indianapolis, IN	Feb-98	46,779	31,200	56,805
New York-Northern New Jersey-Long Island, NY-NJ-CT-PA	Mar-98	61,601	43,388	59,696
Philadelphia-Wilmington-Atlantic City, NJ-DE-MD	Feb-98	59,238	39,666	59,842
Pittsburgh, PA	Dec-97	46,937	39,998	60,466
Raleigh-Durham-Chapel Hill, NC	Mar-98	58,510	47,403	Not available
Rochester, NY	Jan-98	52,000	Not available	51,272
San Francisco-Oakland-San Jose, CA	Mar-98	71,864	56,344	71,771
Seattle-Tacoma Bremerton, WA	Dec-97	49,920	36,005	58,677
Tampa-St. Petersburg-Clearwater, FL	Dec-97	50,003	Not available	62,338

SOURCE: U.S. Department of Labor, Bureau of Labor Statistics, National Compensation Survey

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supply and demand conditions for different types of workers in each region, or whether they are due to differences in the kind of work performed in occupational categories among the regions.

TABLE 15. Median Salary for Computer and Information Scientists

Region	With Degrees in Computer and Information Sciences	Employed As Computer and Information Scientists
Pacific	$53,000	$55,000
Middle Atlantic	50,000	52,000
New England	50,000	50,700
Mountain	49,000	51,000
East North Central	46,000	49,000
West South Central	46,000	50,000
South Atlantic	45,400	50,000
East South Central	44,000	45,000
West North Central	41,500	48,000

SOURCE: National Science Foundation, SESTAT data

National Science Foundation's SESTAT Database

The National Science Foundation's SESTAT database provides regional salary information on core IT workers for those with degrees in computer and information sciences (regardless of their occupation), as well as for those employed as computer and information scientists (regardless of their academic preparation). This data is displayed in Table 15. The Pacific region has the highest median salary in both categories, $55,000 for those employed as computer and information scientists, $53,000 for those with degrees in computer and information sciences.

Hot Skills, Hot Jobs by Region

RHI Consulting's *1999 Salary Guide* provides a detailed regional perspective on the hottest skills (see Table 16).

In addition, surveys conducted by RHI Consulting provide insight into the hottest jobs—as measured by strongest growth in U.S. corporate IT departments—by region:[57]

TABLE 16. RHI Consulting's'List of Hottest Skills in 1999

New England	networking, software package implementor/installers, network administrators, programmers, Internet/intranet developers
Middle Atlantic	C++ and Java programmers, network administrators, installation and support specialists, systems analysts, Internet/intranet developers
South Atlantic	mid-level networking professionals skilled with LANs, senior-level analysts with Visual Basic programming skills, Internet/intranet developers, software developers
East North Central	IT managers, programmers, PC support technicians, networking professionals (especially those with experience designing and maintaining WANs), Internet/intranet developers
West North Central	networking professionals, Internet/intranet developers, software programmers, help desk support professionals, database architects and administrators
East South Central	software developers, networking professionals, PC technicians, Internet developers, e-mail installation experts, database professionals
West South Central	networking professionals, Internet/intranet developers skilled in C++ and Visual Basic
Mountain	networking professionals, applications developers, UNIX/Windows NT systems administrators, business systems analysts, quality assurance professionals
Pacific	networking professionals; Internet professionals; relational database administrators and architects; Oracle and Access database technologists; Visual Basic, C++ and Java programmers

SOURCE: RHI Consulting

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- Mid-Atlantic States (New York, New Jersey and Pennsylvania) expressed strongest growth for networking professionals (29 percent), and applications developers (22 percent).
- West North Central (Minnesota, Iowa, Missouri, North Dakota, Nebraska and Kansas) reported the most growth in their IT departments (11 points above the national average) and expressed strongest growth for Internet/Intranet development professionals (25 percent) and help desk/end-user support (23 percent).
- East North Central (Ohio, Indiana, Illinois, Michigan and Wisconsin) showed fastest growth in Internet/Intranet development professionals (24 percent).

VIII. REPORT OF THE NATIONAL DIALOGUE ON THE INFORMATION TECHNOLOGY WORK FORCE

The material that follows on encouraging young people to pursue and prepare for technical careers, post secondary IT education, training the incumbent IT work force, and groups underrepresented in the IT professions is drawn largely from the National Dialogue on the Information Technology Work Force.[†]

In addition, data and information garnered from academic studies, media reports, commentary, and Congressional testimony have been included to enrich and amplify this presentation of discussion and ideas. Descriptions of a wide range of efforts focused on strengthening the U.S. technical work force are provided.

The resounding conclusion from our dialogue is that there is no "silver bullet" solution to the IT work force challenge.

This presentation includes suggestions for additional steps that business, government, and the education community can take to strengthen America's IT work force. **It is important to note, the resounding conclusion from our dialogue is that there is no "silver bullet" solution to the IT work force challenge, rather the answer lies in many stakeholders undertaking a wide range of initiatives, both large and small. Thus, the suggestions for key stakeholders presented in this report provide actions that are, for the most part, well within the reach of individual stakeholders in the business, government, and education communities.**

Encouraging and Preparing Young People to Enter Technical Education and Careers

The United States needs to do a better job at encouraging and preparing young people to enter technical education and careers.

At the town meetings, there was general consensus that the United States needs to do a better job at encouraging and preparing young people to enter technical education and careers. Discussions focused on three major themes: improving the image of the technical professions to make them more attractive to young people; providing better information about technical careers to students, their parents, and teachers; and strengthening K-12 math and science education.

[†] Including reports of the stakeholder dialogue carried out in preparation for the National Information Technology Work Force Convocation (Fall/Winter 1997); Maryland Town Forum on Developing a Competitive Information Technology Work Force, Montgomery County, Maryland (May 1998); Gulf States Regional Forum on Developing a Competitive Information Technology Work Force, Jones County, Mississippi (June 1998); Hudson Valley Information Technology Work Force Challenge, New Paltz, New York (June 1998); Pacific Northwest Regional Forum on Developing a Competitive Information Technology Work Force, Bellevue, Washington (August 1998); Women in Technology International Conference, Boston, Massachusetts (October 1998); The Information Technology Worker Shortage: An Opportunity for North Dakota, Bismark, North Dakota, (October 1998); Arizona Town Forum on Developing a Competitive Information Technology Work Force, Phoenix, Arizona (December 1998).

Improving the Image of the Technical Professional

Town meeting participants identified the image of the technical professional as an important factor in shaping young people's attitudes about careers in science and technology. Many people have a distorted, negative image of IT workers, scientists and engineers, perceiving them as highly intelligent, but socially inept or absent-minded "geeks" or "nerds." The media play an influential role in shaping these public perceptions.

Unflattering images of scientists and technologists have populated film and television programming for decades,[58] [59] from Dr. Strangelove, the eccentric creator of the doomsday machine in the 1960s, to the equally eccentric, absent-minded Doc Brown who created the DeLorean Time Machine decades later in *Back to the Future*. Negative images persist today. For example, while one technology-savvy group has gained cult status among young television viewers, the *X-Files'* Lone Gunmen aren't portrayed as mainstream technical experts, but rather as a group of isolated conspiracy theorists. Women and minorities are infrequently portrayed in technical roles; typically, scientists and technologists are portrayed by white males.

The print media also perpetuate such images. A prominent business magazine ran an article on the IT work force with its title imploring "Send Nerds[60]," while a news story in one of the Nation's most prominent newspapers referred to the pioneers of the Internet as "venerated propeller-heads.[61]"

Many children and adults embrace these stereotypical images, and have limited exposure to the wide variety of careers and people in the IT, science and engineering fields. In preparation for the IT Work Force Convocation, a group of students from Missouri in the sixth and ninth grades was asked to draw a picture of an IT worker. Prevalent among the images were bow ties and bald heads, pocket protectors, pants that were too short, and nearly all of the IT workers portrayed wore glasses. Of the 160 pictures of IT workers submitted by the students, only 16 of them portrayed women.

For most young people, the label of "nerd" or "geek" is to be avoided. At the Boston Women in Technology International Roundtable, a government official pointed out the hazard of being a smart kid on television. "Essentially, when you watch kids' TV programs and movies, anybody who's smart is ridiculed in some way."

Image is an important attribute of the profession because it translates into the question, "Can I imagine myself in that role?" The "image" problem undermines efforts to attract young people into programs that would prepare them for technical careers, and leaves adults without the knowledge to guide children into these fields, or to prepare themselves for new roles in the work place.

At the Maryland town meeting, an industry association representative talked about the role of television in creating images of the technical professional. "For some of us, in our generation, television had so much to do with what we became in life. We became lawyers because of *Perry Mason*. We became doctors, perhaps, because of many of the medical shows on TV....The problem I see today is, if you don't have a

"It's hard to make good grades and express an interest in science and math because the standard is to 'be cool'."

"When you break the standard, people criticize. People would always call me 'Smarty Urkel.' Junior high was the very worst."

Shaun, College Freshman

very good image in the media for making high-tech, for making engineering, for making science really attractive, if you don't have—dare I say it—a Leonardo DiCaprio playing a heroic engineer, you are not really going to be able to affect how our children are going to be looking at career choices."

An industry representative in Arizona pointed out the positive influence images can have. "...I know one of the role models I had when I was growing up, in fact, was a TV personality. It was Greg Morris of *Mission Impossible*, the original *Mission Impossible*. And he was the brains. He was the technological brains of that group...And I am not going to say he was the primary reason why I went into engineering, but certainly he was an influence."

The television and film media have offered positive images of scientists and engineers. In the film *Apollo 13*, a NASA engineering team works amidst a crisis and under enormous pressure to bring the disabled spacecraft and its astronauts back to Earth safely. Positive images have also included the portrayal of women as scientists, for example, Helen Hunt's Jo Harding, the tornado chaser in *Twister*, and Jodie Foster's Ellie Arroway, the astronomer searching for extraterrestrial life in the film, *Contact*.

Scientists are seldom seen on prime time television. In a study of the occupations of characters in prime time dramatic entertainment from 1994-1997, two percent of the characters were scientists, and 75 percent of those scientists were portrayed as white males. When compared to all occupations on prime time television, scientists were more likely to be portrayed as heroes.[62]

Television offers many examples of real life scientists and engineers. The PBS program *NOVA* features technical professionals from a wide range of disciplines. Natural scientists are frequently featured in programs about nature and animals. Today, many local television weather forecasters are meteorologists and offer snippets of information about meteorological science.

Still, participants in the national dialogue suggested that efforts are needed to improve the image of the technical professions. This would include explaining the important contributions science and technology make to our economy and quality of life. Identifying and highlighting role models could help young people and their parents learn that technical workers are normal people who perform a wide range of interesting and exciting jobs in science and technology.

Participants also suggested that industry and government open a dialogue with the entertainment industry, as well as the national and local media to encourage these influential shapers of image to improve their depiction of technical professionals, and expand and improve the quality of national and local science and technology reporting.

Some organizations have tried to tackle the image problem. The ***Sloan Foundation Initiative in Public Understanding of Science and Technology*** is an effort to improve public understanding of science, and the role of scientists and engineers in shaping the world around us. Foundation grants have supported the writing of books on major technologies of the 20th century, including radar, commercial aviation,

> *"The problem I see today is, if you don't have a very good image in the media for making high-tech, for making engineering, for making science really attractive, if you don't have—dare I say it—a Leonardo DiCaprio playing a heroic engineer, you are not really going to be able to affect how our children are going to be looking at career choices."*
>
> *Industry association representative*

television, the computer, and medical imaging. Some of these books have served as the basis for public television documentaries. Other book projects include an American history textbook to put science and technology into the story of American history, and books and a CD-ROM on the great engineering developments of the past two centuries. The Foundation provides support for public television and radio programming on science and technology. In addition, the Foundation has made grants to leading film schools to encourage the next generation of writers and producers to develop films and television programming on science, technology, scientists, and engineers.

Other organizations have developed national campaigns to get their messages across to the public. The National Action Council for Minorities in Engineering's public service advertising campaign, ***Math Is Power,*** provides students and parents with information about the importance of math and science. Launched in partnership with the Advertising Council, the campaign reaches students and parents through radio and television public service announcements, brochures, billboards, bus shelters, class room walls, and the Internet, as well as materials in newspapers and magazines. A brochure for parents lists careers that use math and science, informs them about the value of studying math and science, describes how they can encourage their children, and recommends math and science courses children should take.

Image of the U.S. Armed Forces

In much the same way that people have a distorted, often negative image of IT and other technical workers, the public often has an inaccurate and sometimes negative image of the U.S. Armed Forces. The subject of countless movies, the military is often portrayed as being either incredibly heroic and capable or, equally as often, vilified as the source of much of the conflict and strife in the world. The media, particularly the entertainment industry, play an influential role in which image is conveyed. In the interest of a better public understanding of the U.S. Armed Forces, the Defense Department has a number of programs to foster a more accurate and positive picture of the military and how the public is served.

One of the missions of the ***Department of Defense Directorate for Programs and Community Relations*** is providing technical assistance to film and media productions portraying the armed services when requested by a production company. When a film is considered to be of informational value and in the best interest of public understanding of the Armed Forces, the office will assist in the production of the film, making personnel and equipment available on a reimbursable basis. In addition to ensuring that the portrayals depict a feasible interpretation of military life and the Armed Forces, the office requires that its participation serves to support the Armed Forces recruiting and retention efforts. At the local level, military installations across the country co-sponsor outreach events with local communities. Such events highlight how a particular facility serves the local community in terms of jobs provided and as a source of technology and skills.

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Steps to Improve the Image of the Technical Professions

Government and the private sector should work together to support and develop national information and advertising campaigns to improve the image of the technical professions, and communicate the portfolio of skills needed to thrive in the new economy.

- Information products in a variety of print, video, and digital media should be tailored to reach parents, students, teachers, and guidance counselors. Messages should focus on the vital role science and technology play in the economy and our quality of life. Materials could explain that most jobs in the future will require some technical skills, and that science, technology and IT work involves a broad array of exciting careers. The campaign could identify and highlight "normal" role models, including women and minorities, what they do, and their contributions to society. More basic material could be developed to introduce K-6 students to the concepts of work, industry and technology.

Industry and government—at the Federal, state, and local levels—should establish a dialogue with those who heavily influence perceptions about people who make and use science and technology.

- At the national level, industry and government could establish a dialogue with the entertainment industry and the press to improve the image of technical professionals and the portrayal of their work in television, movies, and the printed media. State and local government officials could join regional businesses in establishing a dialogue with local media to encourage a more positive portrayal of technical workers, and expanded coverage of the community's science and technology activities and those who participate in them.

Technology-intensive companies and organizations could invite members of the community in which they reside to visit and see how such organizations work, how they use technology, their working environments, and their contributions to the economy and quality of life.

The Federal government could expand its efforts to promote Federal scientists and engineers as role models, and publicize the exciting diversity and value of their work.

- This would have the added benefit of raising public understanding of science and technology, and the value of the public's investment in research and development.

What Do These Images Say About People Who Develop and Use Science and Technology

Dr. Strangelove (Peter Sellers), *Dr. Strangelove*: Eccentric scientist develops doomsday machine that can't be turned off.

Professor Sherman Klump (Eddie Murphy), *Nutty Professor*: Severely overweight science professor concocts formula to transform himself into hip playboy to attract girls.

Steve Urkel (Jaleel White), *Family Matters*: Brainy teenager with nasal voice, in bow tie, glasses, and short pants. Uses science and technology; can't get the girl.

Doc Brown (Christopher Lloyd), *Back to the Future*: Eccentric inventor of time machine.

Professor Wayne Szalinski (Rick Moranis), *Honey, I Shrunk the Kids:* Nerdy scientist accidentally shrinks his kids to inch size.

Lt. Commander Montgomery "Scotty" Scott (James Doohan), *Star Trek*: Chief engineer who fixes the ship and restores the power in the nick of time.

Lt. Commander Geordi LaForge (LeVar Burton), *Star Trek: The Next Generation*: Chief engineer who keeps ship running and performs other feats of engineering.

Angus MacGyver (Richard Dean Anderson), *MacGyver*: Uses ingenuity, physics, chemistry, and objects at hand to get out of difficult and dangerous situations.

Barney Collier (Greg Morris), *Mission Impossible*: Technical wizard of the mission impossible spy team.

Dr. Julia Kelly (Nicole Kidman), *Peacemaker:* Nuclear weapons expert uses knowledge to track stolen nuclear weapon, and disarm nuclear device.

NASA Engineering Team, *Apollo 13*: Uses engineering and creativity to bring astronauts back alive in spite of disabled spacecraft.

Dana Scully (Gillian Anderson), *X-Files:* Uses forensics and scientific thinking to explain strange and seemingly paranormal events.

Colonel Sam Daniels, MD and **Major Salt** (Dustin Hoffman and Cuba Gooding), *Outbreak*: Scientists identify strain of deadly virus, find host, and develop remedy.

Ellie Arroway (Jodie Foster), *Contact*: Astronomer searches for extraterrestrial life.

Professor Roy Hinkley (Russell Johnson), *Gilligan's Island*: Uses knowledge of science and engineering to make life better for castaways in their tropic island nest.

Jo Harding (Helen Hunt), *Twister*: Scientist chases tornados to test new method to gain information about tornados.

Dr. Rae Crane and **Dr. Robert Campbell** (Lorainne Bracco and Sean Connery), *Medicine Man:* Field researchers search for cancer cure in rain forest.

Developing Young People's Interest in Technical Careers

Town meeting participants identified the K-12 years as the critical period for generating student interest in science and technology careers. For lack of knowledge and interest in such careers, students may fail to take the appropriate courses in math and science needed to help prepare them for a technology-intensive workplace in a rapidly changing economy.

Young people form opinions about careers before they graduate from high school, and middle school is seen as a key decision-making point. The President and CEO of a large aerospace firm noted that "...if you intercept a student in his junior or senior year and ask, "Are you interested in science, engineering, those kinds of fields? Will you take those kinds of courses in college?," the answer tends to be "We've already made up our mind." He went on to say that the times to influence students along the math and science route "occur at a lower level, perhaps in the junior high, fifth, sixth, seventh, and eighth grades."

Participants emphasized that we do not start developing students' understanding of career opportunities early enough. Many students receive little information about the wide range of interesting and exciting careers in science and technology, the industries that develop and use science and technology, or the education and skills needed to pursue technical jobs. In recent testimony before the Senate Judiciary Committee, an academic expert said, "Currently, few students in high school are aware of what it is that computer scientists do, what academic skills are required, the challenges and activities on the job, and what the economic rewards are."[3]"

Parents play one of the most important roles in influencing children's career choices. For example, a group of students in the third, sixth, ninth, and twelfth grades was asked: What or who has influenced your decision about what you want to do or be when you enter the work force (what job do you want)? At every grade level, parents were identified as exerting the most influence over career choices. Yet, parents often lack information that would enable them to encourage their children to choose a career in science and technology. Teachers and school counselors are providers of career information, but may also lack knowledge about science and technology-based industries. A recent Harris Poll commissioned by the American Association of Engineering Societies confirmed a lack of public awareness of the technical professions. In the survey, 61 percent of Americans felt that they were not very well or not at all informed about engineering and engineers.

Due to a lack of career information and encouragement, and few positive role models, many students at an early age dismiss the notion of or never develop an interest in a science or technology career. The challenge was summed up by an Arizona economic development official, who said "So how do you begin to educate an entire population, an adult population about what is possible in the world of work, and the world of commerce and the world of enterprise, and how do you build an entrepreneurial spirit and a commitment to work unless you have an adult population who can understand that and communicate it to the next generation?"

"The main mistake we made as a nation was to turn science and math into an elite club. Math and science competency should be fundamental for every student, not just for those with the very best grades."

Barbara MacPhee,
Principal, New Orleans Center for Science & Math

"So how do you begin to educate an entire population, an adult population about what is possible in the world of work…"

Arizona economic development official

At the town meetings, a number of ways to increase science and technology career awareness were discussed:

- *Information on Careers and Industry*. Company visits for middle school students were viewed as a good way to introduce them to technical careers and high-technology work settings. Maryland high-tech organizations sponsored a technology career fair to bring middle school students and their parents together with companies to discuss the kinds of careers that are available. An Arizona industry representative suggested that kiosks be placed in libraries which provide information about a region's industry clusters and the jobs in those clusters, so students and parents can become familiar with job titles and content.

  The ***Sloan Foundation's Career Cornerstone Series*** is a collaborative effort with 11 engineering, mathematics, and physical science professional societies to provide materials in a variety of media formats which describe some of the career paths open to engineers, mathematicians, and physical scientists. Videotapes provide a look into the career paths in these fields, and CD-ROMs offer information on degree programs, salary ranges, employer data bases, Internet links, and first-hand career experiences told through engaging profiles. Career planning tools include self assessment exercises, and other general career planning and management information and tools. Each Cornerstone Partner Society has developed a career web site with information on each field and current career options.

  The 3M Foundation and Minnesota State Colleges and Universities sponsored the development of the ***Technical Careers Tool Kit***. The tool kit provides educational and motivational materials to promote awareness of career opportunities in technical fields and the importance of two-year post-secondary technical and career education. The kit is now being marketed to employers and educators nationwide and is designed to help them work together to create cooperative programs that provide students with exposure to today's workplaces and technologies. The kit contains video presentations and background materials. The videos show successful School-To-Work activities in action, including workplace visits, internship programs, and high-tech professionals in the classroom. The videos highlight successful school and business partnerships and demonstrate how such activities can trigger enthusiasm among employees. More than 1,000 tool kits have been distributed to employers and educators. http://www.wallacegroup.com

  TECH (Technical Teams Encouraging Career Horizons) is one of 3M's Science Encouragement Programs. Teams of women and men scientists visit junior and senior high schools to inform students—especially girls and minorities—of career opportunities in science and engineering, and of the need to maximize their career options by studying math and science in school. Each year up to 250 TECH volunteers reach 8,000-10,000 students. Most of the schools are in the St. Paul area, but TECH has recently expanded to involve the 3M Austin Center in Texas and there are plans to set up TECH programs nationwide. http://www.mmm.com/profile/community/index.html

- *Student Work Experiences*: Participants at several town meetings saw value in providing internship opportunities and work experiences for high school students. At the Maryland meeting, a small software company discussed its approach to raising student interest. When the company began focusing on computer gaming software, they assembled a group of high school students to work on the design and technical coding. This gave students exposure to the IT sector and allowed them to work with technology in a business setting. Other participants cautioned against young people postponing or giving up college plans to take IT jobs, for fear that we will eat our seed corn of college graduates from which we will need tomorrow's high-level skills.

- *Highlighting Career Paths*: Making career paths more transparent was suggested by an academic expert during recent congressional testimony. For example, as part of the ten-year Memphis (Tennessee) 2005 strategic plan, public-private partnerships are working to articulate K-16 education pathways to create a pipeline to develop the work force needed to support nine targeted industries in the area. Similarly, Arizona has a Career Pathways program which identifies industry clusters and works to guide students over a multiple year period through the appropriate level of course work and training into career cluster groups in which they may have an interest.
- *Informing Educators*: At a number of town meetings and roundtables, participants saw the need to bring educators into industry to gain a better understanding of workplace requirements for the purpose of integrating those requirements into the classroom. At the Maryland meeting, an aerospace company was cited for its work in bringing local educators into industry through tours and summer faculty internships. In Mississippi, 36 companies participate in Industry Education Day when school teachers in both the Jones County School System and Laurel School System have a day of in-service training and industry tours.

> *"We know information technology is already an essential part of the workplace. We must ensure it becomes an essential part of our educational systems as well so that our youngsters are prepared to compete, and keep America competitive in the 21st Century."*
>
> *U.S. Senator Kent Conrad*

The ***Mid-Maryland Career Connections Program*** focuses on the role of teachers in student career awareness and incorporating career development into the school curriculum. The Howard County Chamber of Commerce has teamed with county schools and the Maryland Departments of Labor and Education to give teachers short internships in businesses during school vacations. The internships give the teachers the opportunity to discover first-hand the skill needs of their students' prospective employers. It is anticipated that internships will continue to be offered beyond the life of the program's grant support through partnership agreements with technology-related businesses. Host companies of past internships have included a software encryption firm, a computer and systems integration consulting company, and a provider of cellular phone and communications service. To date, approximately 80 teachers have participated in the program.

Steps to Encourage Young People to Pursue Technical Education and Careers

Business, government, and educators should work together to provide K-12 students, especially middle school students, information on science and technology careers, their rewards, and what education and training are necessary to pursue them. Materials should be developed targeting parents, students, teachers, and guidance counselors.

- Businesses should sponsor job shadowing and mentoring programs.
- Businesses could sponsor career fairs for students and their parents, and career

kiosks in libraries, schools, shopping malls, children's museums, and other locations where video and printed materials would be available about local industries and technical careers in the region.

- Schools could take students on field trips to companies in high-tech industries.
- To make the route to high-technology careers more transparent, state and local governments, and educators could identify K-16 pathways to IT and other technical careers, highlighting career ladders, job market data, and skill requirements. Education and training opportunities could be identified or developed to help students move along these pathways that lead to careers.

Provide hands-on opportunities for students to gain real-world exposure to high technology industry, technical careers, and work experiences.

- Businesses could sponsor internships and work experiences for high school students to expose them to technical work and careers.
- For students with a strong interest and aptitude in science and technology, companies might provide afternoon employment for education credit and intensive mentoring.
- Businesses could sponsor/cooperate on work-focused IT, science, and engineering projects, at school or the company workplace, with projects focusing on the use of the computer (i.e. developing a video game, building helicopters, or managing a manufacturing line).
- Schools could develop after-school and summer courses in IT, science, and technology, and encourage students to participate in the development and maintenance of school-based IT infrastructure.
- K-12 faculty and businesses could work together to create curriculum, and have technical professionals from local high-tech industries speak to students, or teach a class or short course.

Preparing Students for Technical Education and Careers Through Math and Science Education, and Technical Skills Training

Throughout the country, there was universal recognition that improved math and science education in K-12 schooling is essential for developing a high quality technical work force. Governor Locke said that he had heard from employers across the state of Washington that they need people with a higher level of basic skills in writing, reading, math and science, and people who know how to solve problems, work in teams, and think creatively, critically and independently.

A representative of a Maryland school system stressed that preparing students does not mean replacing the role of the private sector for transferring specific skills to the work force. It means preparing youngsters with appropriate skills in mathematics, science, reading, writing and technology with additional competencies in critical thinking, deliberative analysis and communications to handle the demands of today's technologically advanced work force. A successful partnership between the education and business communities will provide a basis to integrate the needs of the employer into the curriculum of schools, not to the exclusion of traditional academic competencies, but as a supplemental extension of the curriculum.

Strengthening Math and Science Education

In a recent international comparison, the *Third International Mathematics and Science Study*, U.S. fourth graders performed well above the international average in science, and were significantly outperformed by students in only one country—Korea. In mathematics, U.S. fourth graders performed above the international average, but were far behind their counterparts in Singapore, South Korea, Japan, Hong Kong, and a number of other countries. By eighth grade, U.S. students lose ground, scoring just above the international average in science, and below the international average in mathematics. By twelfth grade, U.S. students have slipped below the international average in both science and mathematics, performing among the lowest of 21 countries on the assessment of mathematics general knowledge, and among the lowest scoring countries on the assessment of science general knowledge [Tables 17 and 18].

> *"The dialogue throughout the day (at the regional forum) left me optimistic about the prospects of business, labor, academia and government working together to educate and train a work force that will maintain our country's competitiveness well into the 21st century."*
>
> *U.S. Senator Paul Sarbanes*

In national assessments of mathematics and science learning, U.S. students are performing as well as—if not better than—the U.S. students of 25 years ago. However, comparisons of U.S. student achievement with that of other countries provide an important perspective on how well students and schools are performing.[64]

There have been large gains in the proportion of students taking advanced mathematics and science courses in high school since the early and mid-1980s. In 1994, 93 percent of high school graduates had taken biology, compared with 77 percent in 1982. More than half now take chemistry compared with less than one-third in 1982, and one in four now complete physics compared with about one in seven in 1982. U.S. students are now much more likely to have taken advanced mathematics courses in high school than they were in the years past. In 1994, close to 70 percent of seniors had completed geometry, 58 percent had completed algebra 2, and 9 percent had completed calculus. Science instruction in the United States is similar to science instruction in other countries. However, U.S. eighth grade mathematics classes lag behind those in higher achieving countries. While U.S. eighth graders are still focusing on high-end arithmetic—whole numbers, decimals and fractions—students in other countries are learning algebra and geometry.[65]

TABLE 17. 12th Grade Mathematics General Knowledge Achievement

Nations with Average Scores Significantly Higher than the U.S.

Nation	Average
Netherlands	560
Sweden	552
Denmark	547
Switzerland	540
Iceland	534
Norway	528
France	523
New Zealand	522
Australia	522
Canada	519
Austria	518
Slovenia	512
Germany	495
Hungary	483

Nations with Average Scores Not Significantly Different from the U.S.

Nation	Average
Italy	476
Russian Federation	471
Lithuania	469
Czech Republic	466
United States	461

Nations with Average Scores Significantly Lower than the U.S.

Nation	Average
Cyprus	446
South Africa	356

International Average = 500

Source: Third International Mathematics & Science Study, 1998

Table 18. 12th Grade Science General Knowledge Achievement

Nations with Average Scores Significantly Higher than the U.S.

Nation	Average
Sweden	559
Netherlands	558
Iceland	549
Norway	544
Canada	532
New Zealand	529
Australia	527
Switzerland	523
Austria	520
Slovenia	517
Denmark	509

International Average = 500

Nations with Average Scores Not Significantly Different from the U.S.

Nation	Average
Germany	497
France	487
Czech Republic	487
Russian Federation	481
United States	480
Italy	475
Hungary	471
Lithuania	461

Nations with Average Scores Significantly Lower than the U.S.

Nation	Average
Cyprus	448
South Africa	349

Source: Third International Mathematics & Science Study, 1998

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At the Maryland town meeting a cautionary note was sounded about perceptions on the linkage between advanced mathematics and some IT jobs. The president of a contract staffing and training company noted that the universities and colleges in Maryland, the District of Columbia, and Northern Virginia require calculus, linear algebra, and other higher forms of mathematics as prerequisites for admission to information technology programs, while none of the jobs in business data processing require advanced mathematics, only arithmetic.

The U.S. Department of Education makes a major investment in programs to strengthen math and science education, and to prepare Americans for technology-based careers. To improve math and science education, the Department focuses on improving teaching quality through teacher preparation and effective professional development, upgrading curricula by providing schools with good information and resources, providing learning support for students who need extra assistance, and building a research and evaluation base. The Department also is working to connect U.S. classrooms to the Internet, and ensure that all Americans will be technologically literate. Efforts involve helping ensure teachers are prepared to integrate technology into the curriculum, and use the new teaching and learning styles enabled by technology, as well as demonstrations of innovative uses of technology for education and training. The Department leads efforts to prepare students for high technology careers, for example through school to work programs, and to open the doors of college to more students through a range of financial mechanisms. Detailed information on these initiatives can be accessed at the U.S. Department of Education website at http://www.ed.gov.

There are many programs designed to provide hands-on experiences with math and science as a way to encourage students to stick with these subjects, and to provide education and skill development in these areas. Nationwide, ***MATHCOUNTS*** encourages mathematics achievement for seventh and eighth grade students through coaching and math competitions at the local, state, and national level. The program distributes a handbook and coaching materials to schools nationwide which teachers and volunteers use to develop students' math skills through in-class instruction or extracurricular activity. Teams compete in oral and written competitions at local meets, and winning teams can move up to state and national finals. On average, 350,000 students participate in the program each year. Other activities include teacher workshops, minority encouragement programs, and public outreach. Sponsors include CNA, the National Society of Professional Engineers, the National Council of Teachers of Mathematics, Dow Chemical Company Foundation, General Motors Foundation, Phillips Petroleum Company, Texas Instruments, 3M Foundation, and NASA.
http://mathcounts.org

Texas Instruments is a Dallas sponsor of the ***JASON Project***, a nationwide award-winning science exploration program that allows junior and high school students the opportunity to interact with scientists in remote parts of the world using technologies such as satellite communications and robotics. Over the past three years, the JASON Project has reached more than one million elementary and secondary school students

and teachers. In ***Texas BEST,*** Texas Instrument engineers provide advice to students participating in this competition in which the students build remote-controlled robots. Projects are tested against other entries in local and regional contests, and in statewide finals. The company also supports other technology-based competitions, including the Winston Solar Challenge, an international solar-powered car race for high school students.
http://www.ti.com/corp/docs/community/k-12-3.htm

The ***Bayer/NSF Award for Community Innovation***—sponsored by the Bayer Corporation, National Science Foundation (NSF), Christopher Columbus Fellowship Foundation, and Discover Magazine—encourages students to take a fresh look at science and the world around them by asking teams consisting of four middle school children to identify a problem or opportunity in their community and use the scientific process to solve it. For the ten teams selected as national finalists, the Bayer/NSF Award experience includes a week-long, all-expense-paid trip to Epcot Center at the Walt Disney World Resort as part of the Discover Awards for Technological Innovation. While in Florida, the students compete for $36,000 in savings bonds and the $25,000 Columbus Foundation Community Grant as well as attend the Christopher Columbus Academy, a hands-on program in which students work at the park side-by-side with scientists, engineers and other innovators. The 1998 competition included a broad range of students; 60 percent of the entrants were girls and 30 percent were minorities. Two thousand students from an estimated 400 schools across the country participated in the 1998 competition.
http://www.nsf.gov/bayer-nsf-award.htm

There are a number of efforts that help build support networks for budding scientists and engineers, as well as encourage them to develop their knowledge and skills in these areas. For example, the ***Junior Engineering Technical Society (JETS), Inc.***—supported by several engineering societies and organizations, as well as several colleges and universities—provides activities, events, competitions, programs, and materials that involve students with engineers and demonstrate what engineers do. JETS students get to "try-on" engineering while in high school, learning how the mathematics and science they learn is applied to real life. JETS also shows students, parents and teachers how mathematics and science are used to solve technological problems and how the application of these subjects influences our lives. JETS programs, activities, and materials include:

- The Tests of Engineering Aptitude, Mathematics, and Science (TEAMS) program which enables teams of high school students to learn team development and problem-solving skills, often with an engineering mentor, and then to participate in an open-book, open-discussion engineering problem competition. Teams learn how the mathematics and science concepts they are taught in high school are applied to real-world problems.
- The National Engineering Design Challenge (NEDC) is a cooperative program with the National Society of Professional Engineers and the National Talent Network, and challenges teams of students, often working with an engineering adviser, to design, fabricate, and demonstrate a working solution to a social need.

- The National Engineering Aptitude Search+ (NEAS+) is a self-administered academic survey that enables individual students to determine their current level of preparation in "engineering basic skills subjects" (applied mathematics, science, and reasoning). The NEAS+ encourages tutoring and mentoring.
- JETS also supplies a broad range of brochures, books, and videos on engineering and technology disciplines.
  http://www.asee.org/jets

Many town meeting participants indicated the value of mentoring young students interested in math and science, and there are a number of mentoring programs taking advantage of the Internet for on-line mentoring. ***E-Math*** is the U.S. Department of Education's guide to e-mail based volunteer programs designed to help students master challenging mathematics, science and technology. Each program description includes a source for finding further information if interested in participating in or initiating a similar program. Also included are a description of essential elements that characterize telementoring initiatives and a list of useful telementoring resources. The guide lists existing E-mail programs in three major categories: one-on-one mentor relationships, in which an adult adopts a student for a period of time during which regular e-mail contact is made; question and answer services, in which a student can send a subject-related question via e-mail and have it answered by a adult; and links to subject knowledge and interactive databases that supplement classroom activities.
http://www.ed.gov/pubs/emath

Steps to Support and Encourage Young People Studying Math and Science

Develop a wide variety of support mechanisms for students pursuing math, science and technology education:

- Companies and other science and technology-oriented institutions could encourage their technical workers, and schools could encourage their science and math teachers to mentor high school students pursuing science and technology education and careers. This could include mentoring through regular exchanges of e-mail.
- A "Seniors Tech Force" of retired scientists, engineers, and IT workers could serve as volunteer mentors and speakers at schools.
- Under school supervision, student computer chat groups on science, technology, and IT careers could help provide for networking and peer group support. Chat groups could also be established for parents interested in supporting their children in science and technology education and careers.
- Expand opportunities, for example through school-based and other clubs, for young people to pursue science and engineering endeavors. Activities could include exhibitions at fairs and shows, camps, competitions, gatherings, educational fora, electronic networks, etc.

Teacher Quality

Another problem is that many U.S. math and science teachers are not actually trained in their field of instruction. While high school math and science teachers are more likely to possess degrees in math or science, the vast majority of elementary school teachers earned their degrees in education rather than in specific disciplinary areas. In 1993, 41 percent of high-school math teachers had earned a degree in mathematics, compared with just 7 percent of middle school teachers. In science, 63 percent of high school science teachers and 17 percent of middle school science teachers had a science degree. This means many students are taught science and mathematics by teachers who may not have a deep understanding of the subject matter, or be able to convey the excitement and rewards in these fields of study.[66]

Many students are taught science and mathematics by teachers who may not have a deep understanding of the subject matter, or be able to convey the excitement and rewards in these fields of study.

Recent studies have established that the number and kinds of courses taken by mathematics and science teachers do influence primary and secondary student performance. There is a correlation between higher student test scores and teachers who have had more advanced courses in mathematics and science. Studies have also shown that when covering topics on which they were well-prepared, teachers more often encouraged student questions and discussion; spent less time on unrelated topics; permitted discussion to move in new directions on the basis of student interests; and generally presented the topics in a more coherent, organized fashion.[67]

Through its ***Collaboratives for Excellence in Teacher Preparation*** initiative, the National Science Foundation is supporting efforts to improve significantly the mathematics, technology, and science education of prospective elementary and secondary teachers. A basic premise of this effort is that the mathematics, technology, and science that prospective teachers learn as part of their undergraduate education, and the manner in which the courses are presented, have a critical influence on the quality of their teaching. Collaborative projects typically involve cooperative efforts that include science, mathematics, and education faculty and their departments. The large-scale systemic projects are designed to change teacher preparation programs on a state or regional basis and to serve as comprehensive national models.

To improve math and science teaching in the St. Paul, Minnesota area, ***3M's TWIST (Teachers Working in Science and Technology) Program*** allows about 30 science and math teachers from selected school districts to spend six weeks each year during the summer working closely with a 3M mentor on a research project. It provides the teachers with technical experience in an industrial setting so they can learn more about the practical applications of science, mathematics and technology.

Steps to Strengthen Math and Science Teaching

Businesses should advocate vigorously in their local communities for education policies that support rigorous mathematics and science curriculum for all high school students.

Raise the quality of the teaching corps in math and science:

About 51 percent of public school classrooms had Internet access in 1998.

- At the elementary and middle school levels, ensure that there are mathematics and science teachers with an actual degree in the field, and give these teachers the time and flexibility to work as resource teachers to train other teachers. Increase their number at the high school level, and increase the scope of fields (chemistry, biology, physics, etc.) covered by teachers with degrees in these fields.
- To improve the education of teachers, encourage collaborations between schools of education, and college math, science and engineering departments.
- States and/or industry could fund scholarships for college students who will train both in education and math or science in exchange for a commitment to teach in K-12 schools.
- School systems could increase salaries for K-12 math, science and technology teachers.
- Businesses could also play a role in strengthening math and science teaching by funding stipends and scholarships for teacher training in math and science, as well as by helping defray the cost of hiring qualified teachers.
- Businesses and educators should work together to bring professionals with real-world experience into the classroom.

Increase teacher exposure to IT, science, and technology, work in these areas, and the high-technology industries.

- Businesses could sponsor company tours for educators and guidance counselors, as well as sponsor paid summer internships, sabbaticals, and other work experiences for math and science teachers.
- Businesses and school systems could establish programs for teachers to rotate through working in industry—teaching—working in industry.

Information Technology Skills Development

The growing use of computers on the job and the high growth in computer-related occupations have made computer skills an important component of most students' educational portfolio. In many industries, the number of workers who use a computer at their job now ranges from 50 to 85 percent.[68]

IT is being widely deployed in the U.S. K-12 educational system. Today, there are about six students for each computer in K-12 schools, though student access varies. About 51 percent of public school classrooms had Internet access in 1998, up from just 3 percent in 1994.[69] Federal policies such as the FCC E-rate for schools and libraries, and the Department of Education's Technology Literacy Challenge Fund have contributed to this rapid increase in school access to the Internet.

While significant progress is being made, Congresswoman Constance Morella said that "American schools are not yet equipped for the new millennium," pointing out that the most common computer in our nation's schools is the Apple IIC, which was introduced over a decade ago. A representative of a Maryland school system pointed out that the pace of technological change makes computers obsolete rather quickly, and that it is a challenge to not only get computers to every classroom but to keep them up-to-date.

Computer use in K-12 provides early exposure to IT and the opportunity for skill development.

Efforts are springing up to help build IT infrastructure in the K-12 education system. For example, ***U.S. Tech Corps*** is a national non-profit organization dedicated to improving K-12 education at the grassroots level through the effective integration of technology into the learning environment. TECH CORPS recruits, places, and supports volunteers from the technology community who advise and assist schools in the introduction and integration of new technologies into the educational system. Volunteers provide assistance with local planning, technical support and advice, staff training, mentoring, and classroom interactions. To accommodate a wide variety of local educational infrastructures and environments, TECH CORPS is implemented through 43 chapters in 42 states and the District of Columbia. More than 8,000 volunteers participate in the program, and have brought technology and training to more than 1,000 schools nationwide, reaching nearly 15,000 teachers in rural and urban communities. Funding is provided by numerous private sector organizations. National projects include: CyberEd, a classroom on wheels to bring Internet training to educators, parents, and community leaders in Empowerment Zones nationwide; webTeacher, which provides a free, online Web training tool for teachers; and Internet Safety Mousepads, which bring guidelines for safe use of the Internet into classrooms across the country. http://www.ustc.org

In another example, the West Shore School District in Pennsylvania operates the ***Partners in Education*** program which includes an ongoing partnership with companies like AMP Inc. The AMP partnership, which was one of the first, involved bringing engineers from AMP Inc. to the school district's training facility to train technology coordinators from the region in computer cabling standards and termination of fiber optic cable. AMP also installed the first of its kind Multimedia Distribution System (MDS) in West Shore's newest middle school. The overall objectives of the Partners in Education program are to provide opportunities for businesses and community organizations to work together with educators within the structure of the school district, and to facilitate the exchange of educational and informational experiences.
http://www.wssd.k12.pa.us

A student's own interest and skills are influential in career choice, and computer use in K-12 provides early exposure to IT and the opportunity for skill development. The development of students' computer skills is increasingly integrated into instruction, for example studying chemistry using spreadsheets and simulations. According to the National Assessment of Education Progress, 54 percent of U.S. fourth grade math teachers use computers for math/learning games, and 27 percent of eighth grade math teachers use computers for simulations and applications. In the assessment, more than a quarter of eighth grade students said they used a computer at least once or twice a week when they do mathematics in school.

There are a growing number of programs aimed at developing students' information technology skills. For example, in 1996, local community leaders in Omaha, Nebraska recognized that many young people were not obtaining the academic and cultural skills required to compete in the metro area's growing technical labor market. At the same time, local IT companies reported increasing difficulty in recruiting for many high skilled, high wage positions. The ***Workforce Initiative for the Next Generation of Students-21st Century (WINGS 21)*** project at Central High was designed to bring together high school faculty, students and their parents, local technology-based companies, and post-secondary institutions in a unique community partnership to address the education and labor issues that affect metro Omaha's future economic growth. Approximately 46 percent of the students are eligible for free or reduced-cost lunches and come from homes near or below the poverty line. All ninth grade level students at Central High take an introduction to technology course to help them acquire certain basic skills and a rudimentary understanding of the business applications of technology. Included in this introductory course are aptitude testing, and career exploration and counseling activities. This course provides the gateway to more advanced curriculum offerings in six technology career areas: Business/Marketing, Electronic Imaging/Publishing, Multimedia Development, Computer Programming, Computer Systems Integration, and Computer Aided Design. Nearly half the students go on from the introductory course to enroll in the more advanced course offerings. Besides innovative classroom instruction, students also get hands-on experience, internship opportunities with local firms and the ability to earn college credit. A comprehensive program of outplacement services assists graduates in making a successful transition from high school to the work force or post-secondary education. For example, students are brought together with AIM Institute's 55 corporate and university members to experience and explore technology-related careers through internships and other opportunities. An estimated 3,850 students have participated in the program since its beginning in 1996. The WINGS 21 program was named one of the top six technology initiatives for children in the country by the Center for Children and Technology.
http://www.learnlink.org/

Some teachers with IT skills are being hired away from schools to work in the private sector.

At a number of town meetings, concern was raised about the need for teachers to acquire computer skills and retaining teachers who have them. Some teachers with IT skills are being hired away from schools to work in the private sector. At the Pacific Northwest meeting, a business CEO discussed the challenge of developing and keeping teachers with technology skills. "If you are a teacher that understands technology and can offer that to our children, and your pay goes up three percent, five percent, whatever it is, and you know you can go out to the industry and double your wages, that's not going to be sufficient for a long-term strategy." It was suggested that teachers be rewarded for obtaining IT certifications and remaining in teaching, and that industry could help provide such incentives.

A number of efforts are designed to help develop teachers' computer skills. The ***International Technology Education Association*** (ITEA) is the professional organization of technology teachers which strengthens the profession through leadership, professional development, membership services, publications, and classroom activities. ITEA conducts various professional development programs:

- *The Technology Teacher, Technology and Children, The Journal of Technology Education,* TTTe (the electronic version of The Technology Teacher), *Curriculum Brief*, and a variety of other publications and videos provide teaching directions, instructional ideas and networking opportunities.
- Ten primary committees coordinate all aspects of technology education and sponsor dozens of meetings, conferences and exhibits each year.
- An active honors and awards program recognizes outstanding teachers and programs (K-12) from states, provinces and countries that are affiliated with the Association. ITEA also presents award certificates and supports other programs which recognize outstanding efforts in the technology teaching profession.
- A public policy program provides information to government agencies, associations and other special interest groups concerning technology education. The Association strives to provide an understanding of the importance of technology education to the future growth and well-being of all nations. http://www.iteawww.org

Steps to Improve Schools' Capacity for IT Skills Development

Expand technical education/IT infrastructure in schools:

- Businesses could donate IT equipment, software, and IT-related services to schools and keep them up to date.

Strengthen teacher training in IT:

- Create and implement IT curricula in schools of education.
- School systems could reward liberal arts teachers who integrate IT into curriculum, as well as reward teachers who obtain IT certifications and remain in teaching.
- Businesses could work with schools to develop "teaching the teacher" programs in which high-technology industry's technical staff conduct training workshops for teachers.

Challenges in Preparing Post-Secondary Students for the Information Technology Work Force

During the town meetings, participants focused on a number of challenges to better prepare college students for the high-tech work force, including: increasing student opportunities for relevant technical education and skills development, increasing faculty exposure to high-tech industry, ensuring that curricula are up-to-date and impart the knowledge and skills employers need, and ensuring adequate IT education and training infrastructure.

Students need greater knowledge of the work environments to which they will move after graduation.

Increasing Student Opportunities

At many of the town meetings, participants suggested that students need greater knowledge of the work environments to which they will move after graduation. This would increase their understanding of the skills needed to play a productive role in the high-tech workplace, and help illustrate the relevancy of what they learn in the classroom.

Summertime jobs and after school jobs within industry are viewed as a valuable way to give students practical knowledge.

A number of efforts to increase student exposure to the world of work were discussed. A large high-tech company in Washington state described an effort in which faculty would teach theory during the class and then software engineering students went to the company to work on a real project—with real software engineers and a real technical manager—applying what they learned in class. A Maryland academic official suggested that it would benefit students if people in business who are at the cutting-edge of information technology taught a course in higher education or public school institutions.

In Maryland, efforts are underway to increase the number of students preparing for technical jobs. The state established a science, engineering, computer, and technology scholarship program to encourage youngsters in the state to go to Maryland universities, study science and technology and engineering, and stay in Maryland to work for the state's high-tech companies. In another example, the University of Maryland formed a partnership with a private IT school which created an intensive five-week training program to teach COBOL to students of all ages to address the year 2000 problem. Businesses are recruited to sponsor students' training and to hire them upon completion of the program. Participating businesses also contribute to a scholarship fund. After a stint at the sponsor company, a student can draw from the scholarship fund to pay for up to four years of tuition toward a bachelor's degree.

Similarly, in the ***Top HATS*** program, Northern Virginia's George Mason University School of Information Technology and Engineering has created partnerships with local industry and other educational institutions to recruit high-achieving transfer students who have demonstrated academic excellence during their first two years of

college. Top HATS participants enroll in one of four undergraduate programs: computer science, electrical and computer engineering, systems engineering, or urban systems engineering. Sponsoring firms provide Top HATS with tuition support, mentoring, summer employment, paid internships, and employment opportunities upon graduation. The 1998-99 school year was the program's first year, with 15 students participating. Twenty students are enrolled for the upcoming 1999-2000 school year.
http://www.site.gmu.edu

Many students begin their technical education at community colleges, and seek to move to traditional four-year science and engineering programs. However, there can be barriers to making such a transition. A participant at the Mississippi meeting pointed out that, despite encouraging words about upward mobility of students, an individual graduating from their two-year technology programs cannot transfer to a university in Mississippi without losing credits earned in computer classes.

There was also interest in including technical education and training as a component of non-technical education programs such as those in health care, business, education, or marketing.

There is concern that fewer college students will pursue graduate level IT studies, opting instead for lucrative job opportunities as IT workers in industry. The "seed corn" problem could result in insufficient numbers of faculty to train the next generation of students, as well as fewer U.S. master's and Ph.D. graduates for advanced, cutting edge IT work.

Steps To Increase Student Opportunities

Expand student opportunities for technical education, training, and experience.

- Businesses could provide funds for science and technology scholarships for high school students, college students, or current workers who commit to working for a contributing company or in states and regions where the private sector's need for IT workers is growing.
- The business and education communities should develop more hands-on work-study opportunities.
- The Federal government could work with community colleges and computer science/engineering schools, local business communities, and others to establish an IT/e-commerce extension service in which students studying IT assist small and medium-sized firms with IT planning, implementation and problem solving.
- Barriers (i.e., recognizing class credits) to matriculating from two-year IT programs at community colleges to four-year IT programs at universities should be reduced.

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Increasing Faculty Knowledge of High-Tech Industry and Developing Technical Skills

Faculty must continue their professional development technologically.

Town meeting participants identified the need to increase faculty technical skills, keep those skills up-to-date, and increase faculty knowledge of high-tech industry. This would help ensure that teachers are providing students with the knowledge and skills employers want. At the Mississippi town meeting, the CEO of a high-tech entrepreneurial firm, formerly an instructor and administrator at a school of math and science, suggested that faculty must continue their professional development technologically. "You need to continue to allow your instructors to go on to the CNE track, the CNI tracks, the Microsoft tracks, the Cisco tracks, the more advanced tracks or you will quickly fall behind." However, it was noted that teachers are often not compensated for attaining such skills, and it was suggested that the private sector provide some rewards for teachers who attain these skills and stay in teaching.

"Mississippi has addressed the education of its future IT worker through 7th-11th grade tech prep initiatives, the implementation of two-year college degrees in advanced network technologies, and university articulated curriculum to complement the two-year college advanced technologies programs..."

Dr. Catherine Cotten,
Director of Information and Research
Jones County Jr. College,
Ellisville, MS

With funding from the National Science Foundation's Advanced Technological Education program, Jones County Junior College began their ***Networking Training for Educators*** program to provide training in networking technology to faculty at secondary schools and two-year colleges throughout the state of Mississippi, home to a growing number of high-technology companies. Instructors from around the state come to the campus for intensive four-week workshops designed to help them teach information technology. To receive a full stipend for attending the workshop, a participant must take and pass, at an official testing center, one of the examinations to become either a Novell- or Microsoft-certified network administrator. So far, 70 percent of the participating instructors have become certified.

A participant in the Mississippi meeting pointed to the military model of rotation—three-year tour as instructor, then back into the field—as a way to help ensure industry awareness among teachers. A Maryland business official suggested that faculty spend their sabbaticals in businesses.

Steps To Increase Faculty Exposure and Technical Skills

Increase faculty exposure to IT, science, and technology, work in these areas, and the high technology industries.

- Bring faculty to industry through business sponsored summer internships and sabbaticals, through rotation programs, and through exchange programs for industry and university IT scientists and engineers.
- Colleges and universities should encourage faculty to establish relationships with counterparts in high-technology industry to gain advice and knowledge on technological trends, business needs, and curricula design.

Encourage faculty to increase their technical skills and keep them up-to-date.

- Businesses could fund faculty stipends, sabbaticals, or scholarships to acquire up-to-date IT knowledge and IT skills.
- Reward faculty who obtain IT certifications.

Keeping Curricula Timely and Relevant

The speed of technological change is making it ever more difficult to keep curricula current and aligned with the needs of employers. At the town meetings, concern that the academic community adapts too slowly was raised repeatedly.

The CEO and President of an Arizona software company described Internet time—when a couple of months is equal to a year—and its impact on curriculum development. "I was at an Internet company, they are an e-commerce company now. They used to be an Internet service provider, but that was a couple of weeks ago, and they needed to learn macro media. And Pima County College has a 16-week course in macro media. They said 'I want to know it in six hours. That's because I have a project that's got to be out by next week.' And that is the time that we are dealing with in the IT industry." The president of another IT company in Arizona made a similar comment. "I see a lot of people moving into information technology who do not have the skills. We are talking mathematical skills, logic skills. I am afraid as an employer of getting people who will require an awful lot of training. We have eight hours to learn a new system. We don't have three months or six months. These people have to have the skills...to be able to learn the next generation of Oracle in eight hours."

The speed of change is putting pressure on academic institutions to keep pace, which traditionally do not change quickly. The CEO of a high-tech company in Mississippi said, "You may need to change what you are teaching next year. Historically, in education systems, we don't do that...We get this curriculum developed and we get these courses approved, and then we are going to teach it for ten years. You can't do that anymore." A Mississippi university professor added, "It takes between 18 months and three years to get a developmental course approved and running in this state right now....We can't wait three years to get a new course approved."

It is widely believed that community colleges, private institutions, and non-degree programs are more flexible than four-year public universities in responding to industry's needs by modifying existing curricula and creating new programs. In public institutions, there is often a lengthy procedure necessary to create new programs, and funding limitations for new programs. A Mississippi community college IT instructor agreed that it is being done faster in the community college environment, citing the development and approval of a curriculum on wide area networking taking less than six months. The curriculum was developed in partnership with several high-tech companies. Another participant from the state pointed to an associate degree program that was put in place in three months.

A community college official at the Arizona meeting explained how businesses could help. "In order for us to change our curriculum, we need to hear from not just the human resource representatives from the companies, but we need to hear from our software engineers, we need to hear from our programmer/analysts. We have advisory councils at every one of the colleges that play not just an advisory role, but play a role in determining what we might offer, what we might change. However, where we tend to struggle is getting representation from technical people, from engineers in our council."

An official from a large high-tech employer in Washington state suggested that the sooner companies can give educational partners an idea of where they think technology is going, the sooner schools can begin to adjust their curriculum. This company has appointed computing-related technical people to interact with major universities and colleges. They can discuss on a monthly basis what changes the company sees coming, and how the company can help educators.

Building bridges between industry and academe was a common theme at the town meetings. In Mississippi in 1994, the state legislature passed the *Work Force Training Act*. This act established 15 work force councils in community college districts around the state. The majority of council members are from the private sector, thereby giving that sector, for the first time, a voice in what type of training is done in Mississippi.

Building bridges between industry and academe is a principle behind the ***Global Wireless Education Consortium*** and its ***Practical Work Experience Program.*** The Global Wireless Education Consortium (GWEC) was established in 1997 to increase the quality and quantity of technicians, engineers, and IT specialists to meet the demands of an expanding wireless communications industry. Industry members work with colleges and university partners to develop up-to-date wireless technology curriculum. GWEC provides its members with industry/educator developed wireless curriculum packages for adaptation by two-year, four-year, or Master's level academic programs. GWEC industry members also offer students pursuing wireless education in GWEC partnership schools the opportunity to compete for paid internships and co-ops with GWEC member companies in the Practical Work Experience Program (PWE). The PWE program is developed by schools and industry members to enhance the wireless education of students pursuing computer science, engineering or technician related fields of study. Faculty attendance at industry sponsored training courses and training materials are also provided to member schools without cost. One hundred participants attended a faculty workshop held in the summer of 1998, and the number of participants is expected to double at the 1999 summer workshop. Currently 27 schools across the country offer this curriculum and, by the end of 1999, the total will rise to 35 schools.
http://www.gwec.org

The semiconductor industry has also seen a need to become directly involved with the education community in order to meet its growing technical work force needs. The ***SEMATECH Partnering for Workforce Development*** program was launched in June 1996 to help meet the growing demand for skilled operators and manufacturing and equipment technicians. The program is now managed by the Semiconductor Industry Association. The objective is to increase the supply of skilled workers for SEMATECH member companies by:

- Increasing the number and capacity of schools offering semiconductor manufacturing and electronics-related programs at the post-secondary level.
- Increasing the awareness of the semiconductor industry and semiconductor manufacturing as a career choice.

- Increasing the alternative sources of employees, such as the military discharge population and other sources in addition to the traditional pool of technician recruits with math/science backgrounds.

As a result of the Partnering for Workforce Development program, 80 community and technical colleges in 17 states now offer two-year associate degree or certificate programs that prepare people to work as skilled operators and technicians in the semiconductor manufacturing industry.
http://www.semichips.org and http://www4chipjobs.com

The National Science Foundation is playing a leadership role in strengthening curriculum for technical skills development at the Nation's community colleges. The ***Advanced Technological Education (ATE)*** program promotes improvement in technician education delivered at the undergraduate and secondary school levels. Focused on both national and regional levels, it provides funding to support curriculum development and program improvement for technicians being educated for the high performance workplace of advanced technologies. Curriculum development encompasses the design and implementation of new curricula, courses, laboratories, and instructional materials. Students enrolled in ATE programs at two-year colleges typically earn an associate degree in a science or technology discipline qualifying them for employment or transfer to a four-year institution. Program improvement encompasses faculty and teacher development, student academic support, and formal cooperative arrangements among institutions and other partners, such as industrial internships and cooperative experiences. ATE centers and projects serve as models for other institutions, ensure that students acquire strong backgrounds in mathematics and science, and yield nationally-usable educational products. In fiscal year 1998, the ATE program supported 11 Centers of Excellence and 158 projects. Each year, approximately 250,000 college and high school students participate in the program.
http://www.ehr.nsf.gov/EHR/DUE/PROGRAMS/ATE/ate.htm

The National Science Foundation is playing a leadership role in strengthening curriculum for technical skills development at the Nation's community colleges. The Advanced Technological Education Program promotes improvement in technician education delivered at the undergraduate and secondary school levels.

One of the ***ATE*** Centers of Excellence is the ***Northwest Center for Emerging Technologies (NWCET)*** in Washington state. NWCET's mission is to:

- advance IT education by forging partnerships among business, education and government;
- develop model IT degree and certificate programs which offer education for students entering the job market and training for those upgrading their skills;
- develop IT educational products and services, including distributed and online learning applications, to support the model degree and certificate programs; and
- serve as a national clearinghouse for advanced IT education.

NWCET has developed a set of skill standards for eight career clusters in information technology. Key in the retraining of incumbent workers is NWCET's participation in Washington State's Worker Retraining Program, a program that provides financial aid to those who have been laid off from their jobs which allows them to return to school to obtain marketable skills. This program has allowed Bellevue Community College, and other community and technical colleges to develop new advanced technology programs to train people for the growing number of IT jobs, as well as to develop short-term training programs to assist with welfare reform transitions. Each year, NWCET helps to provide retraining to hundreds of individuals who continue on to successful careers in the IT industry. http://www.nwcet.bcc.ctc.edu/about/about.htm

While industry needs the skills often produced in short-term intensive skills training programs, such programs may not provide enough emphasis on the underlying knowledge and problem-solving needed for a rapidly changing business and technological environment. If workers do not possess the underlying knowledge and skills, their specific technical skills will become outdated in a few years.

At the town meetings, there was also concern about creating the proper balance between traditional science and engineering programs, and providing students with currently marketable technical skill sets employers want. Companies want employees who are prepared to meet the demands of the job from day one. While industry needs the skills often produced in short-term intensive skills training programs, such programs may not provide enough emphasis on the underlying knowledge and problem-solving needed for a rapidly changing business and technological environment. If workers do not possess the underlying knowledge and skills, their specific technical skills will become outdated in a few years. According to the CEO and president of an Arizona software company, "the latest version of Oracle probably is not all that important in reality because Oracle is going to come out with a new version in three weeks anyway. But knowing how a data base should be designed, things like that, those are the important things..."

At a number of town meetings, the need for teaching more than technical skills was raised, including communications skills, leadership, team work, goal setting, and time management. An industry representative at the Maryland meeting said, "You need people who can communicate and who can work as part of a team, make a presentation to a client....It does you no good to have the best Oracle person in the world if they can't speak to somebody else and describe what a client needs." In Arizona, an association executive agreed, "The soft skills, the interpersonal skills and verbal communication and written communication, are just as important as being a good scientist or a good C++ programmer or understanding Java."

A growing IT training enterprise—at community colleges and proprietary training schools— provides many students and workers with specialized skills for which they receive certificates that employers value as a demonstration of competency. These programs typically involve a combination of classroom instruction, lab time, and self-study. Programs such as Certified Novell Administrator and Engineer, Microsoft Certified Systems Engineer, Cisco Networking Academy, Oracle Academic Initiative, and the SAP University Alliance Program have been developed by IT hardware and software producers to ensure a supply of workers trained to provide customers with support in proprietary products. In connection with its educational initiatives, Microsoft has established a loan program that has made loans for training expenses totalling $50 million.

In the ***Cisco Networking Academies*** program, high school and college students can acquire the information needed to prepare for the Cisco Certified Network Associate exam. The Networking Academies offer hands-on experience in computer lab settings, using actual information networking equipment to design and build Local- and Wide-Area Networks. As a full partner in this program, Cisco provides program guidance, curriculum development, and basic networking resources for school computer labs. The school provides dedicated teaching resources and computer labs which meet specific minimum requirements. The program was formed in response to the lack of expertise in schools and colleges that was needed to deploy Cisco technologies. There are currently 1,159 academies offered in 50 states and in the District of Columbia. In Mississippi, site of an IT town meeting, the Cisco program is being deployed at community colleges and high schools throughout the state. http://www.cisco.com/edu/academies/

Similarly, ***Southern Methodist University's Advanced Computer Education Centers*** are dedicated to serving the communities in which they operate by providing individuals and corporations with technical education in the latest Microsoft, Novell, and UNIX platforms. Operated by the School of Engineering, the centers provide the education necessary to prepare for the IT industry or to upgrade existing skills. Each of the four centers (Richardson, Plano, Houston, and San Antonio) offers a complete Microsoft (356 hours) MCSE curriculum, Novell (248 hours) CNE Curriculum, UNIX (160 hours) curriculum, and C and C++ (160 hours) curriculum taught by certified instructors using official course materials. Since its inception in 1996, more than 4,000 students have received high quality instruction in MCSE certification and Novell courses. The centers participate in private industry-sponsored internship programs in which students develop skills on the job as they attend courses. http://www.seas.smu.edu/netech

Participants believe that certificate holders need a broader technical education in order to acquire new knowledge and skills when old ones are made obsolete by technological change.

Concern was raised that technological change could eventually devalue such certifications based on narrow, technology-specific skill sets. Participants believe that certificate holders need a broader technical education in order to acquire new knowledge and skills when old ones are made obsolete by technological change.

Steps To Improve Curricula Quality, Timeliness, and Value

Improve the quality and timeliness of post-secondary technical education through business involvement and college/university responsiveness.

- Businesses can play an important role in improving the quality, timeliness, and relevance of technical education programs by participating on university and college advisory boards.
- Businesses and two- and four-year academic institutions should work together to bring professionals with real world experience into the classroom.
- Businesses could lend their knowledge and advice in technical curriculum design, for example by making company technical professionals with state-of-the-art knowledge available to schools for this purpose, and/or to serve as an ongoing source of expertise and advice.
- Colleges and universities need to develop additional ways to determine the types of training needed by employers, such as regular surveys or focus groups with area business leaders, and find faster ways to develop and adapt curriculum and faculty training to keep pace with technological change and business needs.

Strengthen technical program curricula.

- To better prepare students for the job market, certification components could be offered in traditional, four-year computer science/engineering college programs.
- Develop partnerships between science and technology departments and business schools to provide business majors and MBAs with technical skills, and offer people graduating in liberal arts, social science, and other non-IT fields two or three IT/programming courses in the conduct of their college studies.
- Provide some training in commercial practices, tools, and environment during or after students earn their four-year technical degree to prepare them for the commercial environment and to ensure that their technical skills are up-to-date.
- Develop curriculum components in areas such project management, entrepreneurship, human resources management, etc. to prepare technical professionals for non-technical aspects of their jobs.

Pressures on the Infrastructure

Recruiting and keeping qualified teachers is a problem. A community college teacher from Mississippi pointed to the lure of industry. "That's the first thing people say to me when I tell them I've got my CNA (Certified Novell Administrator). When are you going to go out into industry? You can make a lot more money in industry." Another academic official noted: "About a few months ago, we had a statistic flow across our desk. Nine people from the University of Mississippi's IT department had resigned in a month for $30,000 increases. We are bleeding out IT professionals."

"Nine people from the University of Mississippi's IT department had resigned in a month for $30,000 increases. We are bleeding out IT professionals."

Academic official

At a number of town meetings, university officials reported that their IT programs were turning away qualified students. A college official described pressures at the University of Arizona, indicating that the school did not have enough resources, including faculty, support assistance, technical support, and infrastructure such as access to computer facilities, access to technology, and access to software. Several Washington higher education institutions' IT programs were described as oversubscribed. This was also cited as a problem in the Hudson Valley, New York area. A Mississippi academic official described pilot fast-track programs in computer networking technology and telecommunications, noting that they do not have enough classes or enough space to handle all the applicants and students.

Some industry-led efforts are working to strengthen the IT infrastructure in schools. The ***Great Plains Education Alliance Network*** donates software and other learning materials for colleges and universities to establish accounting and computer science curricula. Members receive software, sample data, technical support, and lesson guides. These programs assist educators in exposing college-level students to accounting, financial management, and computer science software, helping them to experience real-world technologies and be better prepared for entry into the workplace. More than 200 universities, colleges and high schools have benefited from the Great Plains Software Education Alliance Network Program. Students are learning how advanced technologies--such as Great Plains Dynamics and Dexterity, Microsoft Windows 95, NT, and SQL Server, Lotus Notes and the Internet--are changing computer sciences, accounting and financial management, and management information systems for businesses of all sizes. An estimated 3,000-4,000 students currently use the software each year and that number continues to grow as more schools implement the software in their curriculum. Diverse internships and career opportunities are available in a wide range of positions including: marketing, software development, technical support and administrative. http://www.greatplains.com.

"The biggest issue for us and our students is not in keeping our programs current but in finding and keeping qualified IT faculty. Why should someone teach at a community college when he can earn twice or three times as much in private industry? We've got to start thinking creatively to both find and retain good IT instructors."

President Jean Floten
Bellevue Community College

Digital infrastructure is increasingly being used to deliver education and training. Many learners, parents and job holders need training at more convenient times, and distance learning can provide training at different times and days of the week, unbounded by geography. It can also provide "just-in-time" skills upgrading that IT workers need on an ongoing basis to keep their skills up-to-date. The Southern Regional Electronic Campus, which includes Duke, University of North Carolina, and the Universities of Tennessee, Alabama, and Georgia, put more than 100 courses online. Maricopa Community College in Arizona has about 180 Internet courses. However, a business official in Maryland cited a law that limits the ability of community colleges to offer their special courses across county boundaries. "In the age of the Internet, this is absurd. This means that people in Howard County can't get the best that Montgomery County has to offer, but if Montgomery County puts it online, people in Delaware can see it, but you can't log on to it as somebody living in Howard County."

Steps To Improve The Infrastructure

Take steps to identify and correct problems in the IT education infrastructure.

- The education community should examine the adequacy of infrastructure for four-year IT-related degree programs (seats, equipment, and faculty).
- Business donation of IT equipment and software to colleges and universities would help expand IT educational infrastructure and keep it up-to-date.
- Faculty who obtain IT certifications should be rewarded for their achievement, as a way to retain them in teaching.
- Businesses could also play an important role in helping defray the costs of recruiting, retaining and maintaining skills currency of faculty.

Nebraska's Applied Information Management Institute

For Omaha, Nebraska, the key to becoming a world communications leader has been the sustained development of a skilled work force and intellectual infrastructure to go along with the excellent telecommunications infrastructure originally installed for the U.S. Strategic Air Command. In response, the Nebraska business community with full cooperation of the educational and government sectors created the Applied Information Management Institute Services (AIM) in 1992. AIM seeks to support local business growth by focusing on the existing business infrastructure and interpreting business needs to the academic community, resulting in needs-focused changes in the curriculum and structure of educational offerings.

The AIM concept includes providing local technology training, as well as the building of long-term partnerships between educational and business sectors. AIM makes locally available to companies high quality, up-to-date technical training that once required travel to other states. AIM also draws upon Nebraska's universities and colleges as a source of technology education for companies and facilitates cooperation between companies and the academic sector. The result has been that two universities have added a college of information technology, a third has added a college of technology, and a variety of post-secondary schools in Nebraska have added dozens of courses for evening and Saturday classes.

AIM also partners with Nebraska high schools in developing appropriate technology curricula at all levels, which address emerging communications and technology issues to better prepare student for the workplace. Because the Institute serves on a number of college curriculum advisory committees, it has been able to create pipelines between local high schools and the State's colleges and universities. The Workforce Initiative for the Next Generation of Students-21st Century (WINGS 21) in Omaha is one such program that brings high school faculty, students and their parents together with local technology-based companies and post-secondary institutions in a unique community partnership built on education and work force issues.

Specific programs sponsored by AIM include:

- **Cybercamp:** K-12 students from the Omaha area participate in a "CyberCamp" to learn World Wide Web development techniques. Students attend instructional sessions on use of the Internet as well as on developing html.
- **Summer Program In Computer Science**: A companion program to Cybercamp, talented high school students are offered the chance to take a course from the University of Nebraska at Omaha's College of Information Science and Technology. Students can take an introductory, college-level course exploring the fundamentals of computer programming and object-oriented design methodology using the visual C++ programming language. Upon satisfactory completion of the program, students will have earned four UNOmaha college semester credits in computer science, which will generally be transferable to most colleges in the country.
- **CareerLink:** The AIM Institute sponsors the CareerLink web site which connects businesses from all over the state with prospective employees based on their specific needs. Applicants can fill out job applications which are electronically directed toward an employer.
- **Internship Program:** The program coordinates student and faculty internships that provide applied business experience, furnishing firms with a new recuiting tool and access to skilled people.
- **Online Mentoring Program:** Participating students are matched up with a business professional who is available at least twice a week, and serves as a mentor for a one month period. During that period, students acquire increased career awareness, greater identification with information technology professionals, and a better understanding of how skills are applied in career fields.

Retraining the Incumbent Work Force

Keeping the Incumbent Technical Worker's Skills Up-to-Date

In the face of rapid technological change, there is a strong need to focus on upgrading the skills of the existing work force. A Mississippi academic official said that the mind set we have in this country is "that when you finish school, you stop, and you don't do that in information technology. It's changing so much." An Arizona academic official suggested that because technologies are evolving so rapidly, the skill sets taught in school may not be the skill sets needed when students graduate. Therefore, retraining becomes critical to provide the work force with the new skill sets that are needed.

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A growing number and wide variety of programs have been established to upgrade the skills of the current IT work force. These include internal company training programs, training programs provided by technology vendors, private training schools, community college and university-based programs, Federal and state programs, and others. Many of these programs focus on developing the skills of low to mid-level IT workers, and include certificate programs at community colleges in areas such as network technician and web design, as well as popular vendor certification programs, for example, those focused on Microsoft and Novell products. These programs provide a limited set of technical skills in a short duration, compared to the knowledge, skill development, and time commitment required for competency in high skill jobs such as computer scientists and computer engineers.

The Employer Decision to Invest in Training

For highly skilled IT jobs—where job growth is the fastest, labor markets tightest, education and training pipeline the longest, and where employers are often exacting in the skills they need—many employers prefer to pay a premium to hire a worker who already fits a specific education and skill profile. Many employers want employees with experience, in addition to technical skills, making it difficult for workers who may acquire technical skills in demand, but lack experience in their application.

In this market, where employers "buy" trained workers, there is little incentive for employers to invest in training. While a worker with technical aptitude may be able to perform productively after a few weeks or months of training, some employers say they cannot afford to wait that long when operating in an environment of short product life and development cycles. Also, in a very tight IT labor market, with rock bottom unemployment rates, some firms fear they will not be able to capture an adequate return on such investments because employees who have had their skills enhanced will be lured away to other employers.

A representative of a Maryland-based academic think tank cited this fear as a barrier to investments in training. "I would say that one of the major barriers in a hot labor market like this for continuous education and training is the fear by an employer that the employees they train will tomorrow find a better job opportunity down the street. That's a real disincentive to employers to invest a lot in the training of their workers...."

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Think tank representative

A representative from a research think tank suggested another reason why industry is not involved in training as much as it needs to be: most companies in the United States are small. "So what you're dealing with for the vast majority of the economy in the U.S. is a lot of small firms who, a) don't really have the time to think about "How do I want to organize the work force in my region," and b) "How would I go about engaging with the educational community?...They're busy running the firm." U.S. Senator Paul Sarbanes noted, "Many firms, particularly small and medium-sized firms, have limited capacity to engage in the kind of significant work force development efforts that we may well need in order to address the skills shortages. Often, they have to forego training initiatives. They try to hire workers away from other companies in related fields, so you get companies trying to outbid one another for an existing pool of skilled workers instead of coming together cooperatively to enlarge the pool of skilled workers."

A new training model was suggested as a way to address some of these challenges. Regional skills alliances would allow employers to share the cost of developing the skills of incumbent workers, dislocated and disadvantaged workers, and new work force entrants. A model for these consortia has been suggested in which industry contributes at least one-third of the money, matched by government funds. U.S. Senator Paul Sarbanes cosponsored legislation with U.S. Senator Joseph Lieberman to establish a program that would encourage the formation of such training consortia around the country to develop information technology skills. A companion bill was introduced in the House of Representatives by Congressman Jim Moran and others. Consortia would bring together stakeholders—such as high technology firms, public agencies, educational institutions, and labor organizations—to map out a program for a region, taking into account particular needs, as well as jobs threatened by economic and technological transitions.

Some companies, however, see training as an absolute requirement. A company vice president in Maryland said "My employees are going to leave if I do not train them. If I don't find better ways of getting them involved in new and emerging technology, they are going to leave my organization. They are highly-motivated to stay on the edge, to move forward, to have new opportunities. Their career is more an expansion of their view of the technical area, rather than moving up a corporate ladder." This company offers an educational assistance program and computer-based training tools that allow employees to have access at any time or place they can tap the company's computer network or web site. The company also invites their suppliers in to discuss technical developments in the supplier companies, and many engineers attend these luncheon programs.

Companies take many different approaches to meeting their internal training needs. For example ***Lockheed Martin Corporation*** has developed a program to retrain members of its large engineering work force to meet the company's critical IT needs. About 500 engineers participate in the two-year program at any time at 12 different locations around the country. In each geographical area, Lockheed Martin worked with a local college or university to develop a customized curriculum to meet the company's need. The training is provided on company premises. Most participants receive a degree, although that is not the major goal of the program. Most of the engineers are trained to be computer or software engineers but they continue to work on IT in areas related to their previous training (e.g., avionics). Trainees receive their full salaries while in training.

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Some companies have set-up their own universities. For example, Solectron Corporation established ***Solectron University*** in 1990 to drive management and employee development for the company and support its philosophy to "hire for traits—train for skills." The University offers classes in a wide array of topics ranging from manufacturing, computer literacy, management information systems, engineering and management skills. There are three major subject areas: Management Development, Technology/Systems Development, and Manufacturing Development. If a company division requires skills training in an area not covered by a class, Solectron University will make arrangements to meet that requirement, including using outside trainers on a temporary basis. All employees are encouraged to take courses at the University, and may do so on company time. Tuition reimbursement for outside education is also available to workers as long as the degree fits the needs of the company. Last year, Solectron University offered 2,800 free classes worldwide to its workers, 1,583 classes were within the United States. http://www.solectron.com

Keeping Training Relevant

Planning for technical skills development requires knowledge of where technology is headed, a challenging proposition in face of the short product life cycles in information technology. This requires greater exchanges of information between high-technology firms and the education and training community, so trainers can develop appropriate programs to address shifts in foundation technologies, as well as provide more specific skills in the technology *dujour*. Since providing IT skills for the current work force requires educating for broad knowledge and skill, and training for specific technologies, educational providers need to examine ways to match the method of skill upgrading to the speed and depth of reskilling needed. IT workers also need information on technological trends, and the skill needs that will flow from them, so they can pursue options for keeping their skills relevant to the market place.

The state of Arizona has developed a draft plan for comprehensive work force development, which hinges on being able to forecast the kinds of job skills that are needed now and in the future. Meetings have been held with human resource professionals representing the state's industry clusters to identify the occupations in those clusters. They have held focus groups of workers who hold those jobs, people who hire for those jobs, and people who supervise those jobs to help identify what skills are needed in those occupations. The skills and competencies required will be communicated back to the school systems and the training providers.

Making Training More Accessible to Workers

The cost and time required to keep employees up-to-date in fast moving fields is a challenge for employers. A participant at the Arizona meeting observed that there is a need to train and reskill people in IT, but organizational downsizing creates situations in which employees do not have time to train or reskill mainly because they are doing more work than in the past. A Maryland academic official suggested that businesses must do their part too by making employee work schedules more compatible with training, including recognizing that many employees have family and other kinds of responsibilities; training cannot always be accomplished after work.

There is growing interest in incumbent worker training programs tailored for convenience, as well as ways to teach skills on a "just-in-time" basis. A community college official in Mississippi discussed the need to accommodate part-time students such as those who are holding down jobs. "We are going to have to offer more night, more weekend classes, and we are going to have to go head-first into distance learning for everyone, possibly through the Internet." Distance learning was cited as a best practice. A representative of an IT professional society said "Internet-based learning networks offer a particularly effective, convenient, and potentially more affordable alternative to conventional classroom and laboratory-based instructional programs..."

"We are going to have to offer more night, more weekend classes, and we are going to have to go head-first into distance learning for everyone, possibly through the Internet."

Community college official

Some concern was raised about the ability to use Federal financial support for training from for-profit training providers. To be eligible for certain kinds of Federal financial aid, including Pell grants and guaranteed student loans, an education and training provider must meet certain requirements, such as being accredited, being authorized to do business in the state where it offers education and training, having been in business for two years, having programs that result in a credential, and offering programs of some minimum length. These requirements follow provisions of the Higher Education Act, and exist in large part to help prevent fraud and abuse. For-profit schools can and do meet these requirements, including some computer training programs that result in certificates. However, a substantial number of computer training programs are not currently eligible for Federal financial aid. They may not have been in business for two years, or they may not meet the instructional time requirements. Many schools have not tried to meet the standards, such as accreditation, required for Federal financial aid. In a hot area such as IT, schools that have enough students and are making ample money without access to financial aid may have little motivation to go through the steps required to qualify for the aid.

Some communities are implementing more comprehensive approaches to training workers, and linking them to potential employers. The ***Northern Virginia Regional Workforce Development Coordinating Center*** acts as a regional information clearinghouse for individuals seeking IT jobs and skills, as well as employers seeking assistance in finding qualified workers with critical IT skills. The center works with employers to create education programs to produce qualified workers, as well as with potential employees to help them identify careers and training programs linked to current and future job openings in the IT field. The web site provides a data base of technology training and education providers, a listing of links related to IT assessment and career development, listings of job vacancies, and information on financing IT training and education programs. As of May 1999, 1,109 students are receiving training at four regional colleges, 614 have completed IT training and 192 students have been placed in IT or IT-related positions. The Summer Technology Program which focuses on developing technology-related interest in middle school students in Northern Virginia had 230 student participants in 1998. In 1999, the program has increased to include 449 students. http://www.nvp.org

The Workplace, Inc. provides work force development by coordinating job, training, employment and education services in the 20 communities of the Bridgeport-Norwalk-Stamford-Naugatuck Valley region of Connecticut. Adults of all ages gain classroom and hands-on training in a variety of activities ranging from reading, math, English, and

general educational development (GED) preparation to job search assistance, and job-specific skill training. Specific skills include computer repair, computer-related design and drafting, and business machine repair. For dislocated workers who need new skills for jobs in demand, one-year retraining scholarships are provided through the JobLink program for individualized programs of education and training at colleges, technical colleges and training institutes. Between July 1997 and June 1998, the program filled 1,701 jobs with 1,144 employers.
http://www.workplace.org

Steps To Train And Better Deploy The Incumbent IT Work Force

Increase industry investment in training to expand the pool of IT workers by reducing the cost and risk of incumbent worker training.

- Employers should establish and participate in consortia or collaborate in other ways to develop regional training infrastructure and provide worker training. This could be accomplished by businesses alone, or in partnership with the local and regional education community, and other stakeholders. The Federal government could provide matching funds to organize and facilitate cooperation among firms in developing these alliances, as well as participate in alliances as an employer in areas where IT workers are needed to fill government jobs.

Expand resources for employees to participate in training programs.

- Employers could provide scholarships, low interest loans, or time off work for employees participating in training.

Expand the accessibility of training for incumbent workers.

- The education community should create greater flexibility in IT training (shorter courses, different times of the day and week, and different locations), and expand the use of teletraining.
- Companies that certify training providers, such as Microsoft, Novell, and Cisco, should work closely with national, regional, and specialized accrediting agencies to facilitate accreditation of their training providers so that students can qualify for Federal financial aid.
- Employers could put IT training on the desktop, or on company networks available to employees at home.

Improve the quality of government-funded IT training for the current work force.

- Government education and training programs need to periodically review their offerings and those of their contract training providers to ensure they are aligned with employer needs, growing career areas, and the jobs markets in which they operate. It is important to ensure that the focus is on meeting the needs of industry and providing training that has employment as its ultimate objective.

Improve the deployment of the incumbent IT work force.

- Government should identify and help remove barriers to greater private sector use of telecommuting, including identifying and disseminating successful telecommuting models.

- Employers should consider expanding their use of telecommuting to tap IT and other technical workers in different geographic regions and in rural areas.
- When large companies announce major lay-offs, the Department of Labor could deploy a quick response team to match dislocated IT workers with IT job openings. This could include establishing mechanisms to link companies with more senior, mid-career workers through a special job and resume bank, and partnerships with professional societies.

Nontraditional Pools of Labor

To expand the size of the IT labor pool, there is growing interest in tapping nontraditional sources of labor, and training workers from these groups for IT jobs. A representative of an IT professional society suggested that the pool of workers available for IT jobs is broader and deeper than commonly thought. This includes college graduates with science and engineering degrees, college graduates with non-technical degrees, down-sized and older engineers, non-degreed technicians with the potential to increase their skills, and mid-career workers. In North Dakota, the Native American community and rural residents are viewed as an untapped labor pool. Others suggest that many down-sized engineers, and IT workers who have exited the profession due to a variety of factors, including lay-offs, could perform effectively and productively in IT jobs if given a few weeks or months of training.

There is growing interest in tapping nontraditional sources of labor, and training workers from these groups for IT jobs.

The potential in nontraditional pools of labor was described by a representative of an aerospace company. "We have a work force coming in now, 18, 19 years old. This work force has grown up basically with computers, very intelligent in that sense. And we bring them into our company and we teach them how to build helicopters and put together and assemble parts. I just see a very, very large untapped resource out there. These individuals that build these products go home and maintain web sites, run servers. So what kinds of things can you do to help us in the industry identify those individuals and to help pool those things, those human resources that are already out there and currently in our companies and provide additional training for them or at least to assist us in providing training."

Several programs focus on training liberal arts graduates for IT jobs. At the Pacific Northwest meeting, ***SAFECO Corporation***, a Seattle-based financial services company, described its program for tapping nontraditional pools of labor. The company has pursued many recruiting practices, but needed to go beyond those by recruiting people with no computer background. The company placed ads recruiting college majors in areas such as music, journalism, and English, and received thousands of resumes. Candidates with college degrees were tested for aptitude and interest, and 12 were selected for the first three-month class in COBOL. The program expanded to handle 30 candidates. The company paid trainees while they were going to school, and increased their salaries after completion of the program.

Similarly, the ***TurnKey Technical Training*** program forges partnerships between American University (AU) and corporations needing technology workers. The program trains liberal arts graduates for entry-level technology positions. The program takes the product of a university (i.e., liberal arts graduates), matches them with companies

interested in hiring such graduates, and trains them for a specific technology position. AU promotes the program to area companies as a means of filling entry-level IT positions with liberal arts graduates with an aptitude for technology. The company hires the students (and pays for the training program) and graduates start as soon as they complete their liberal arts degree.
http://www.american.edu/training

Microsoft is working to recruit and train those leaving the armed services, many who have acquired good technical skills during the course of their military training. The ***Microsoft Military IT Career Initiative***—a partnership between Microsoft authorized training providers and career placement organizations—provides resources and guidance for those interested in pursuing a post-military career in IT. This includes: a skills assessment to determine what type of IT career a candidate might be suited for and what training would be needed, technical training programs, financial assistance, and job placement services. A four-month pilot program in 1998 on four military bases offered training to 1,570 people with about one-third of those beginning a training program through computer-based, at-home training or instructor-led training. The full scale program was launched in February 1999. Information on the initiative is provided through the U.S. Department of Labor's Transition Assistance Program at 160 military bases nationwide.

There is also interest in moving highly-skilled, mid-career technical workers who have been displaced into the IT professions. For example, the ***Massachusetts Software Council Fellowship Program (SCFP) Inc.*** is a private non-profit corporation providing displaced, but highly skilled workers to the software industry through retraining and education. Initiated in 1993 under the sponsorship of the Massachusetts Software Council and the Commonwealth of Massachusetts, the SCFP provides a bridge for mature professionals who are making a transition from other technical industries to find careers in the software industry. The integrated learning approach includes a five-month on-site company project experience and weekly seminars to keep the Fellows current on issues unique to the software industry. Classes start approximately every two months. More than 450 individuals (a 95 percent rate) have graduated from the program and have been placed in companies. Graduates earn a starting salary that is 93 percent of their previous wages and reach their previous salary or surpass it within a year's time. Positions into which graduates are placed include software engineers, quality engineers, customer support, marketing and sales, and technical documentation. The program is funded through grants from the U.S. Department of Labor, Title III, *Job Training Partnership Act*, funds from the Commonwealth of Massachusetts and the states of Connecticut, Rhode Island and New Hampshire, as well as from participating companies involved in the retraining program.
http://www.swcouncil.org/fellows/index.htm

The focus of ***SeniorTech*** is older workers. SeniorTech partners with the University of California to retrain older IT workers in COBOL skills to address the year 2000 problem. Some 15,000 older workers have placed their names in the SeniorTech data base.

Mature and disadvantaged workers are the focus of ***Green Thumb, Inc.*** Chartered in 1965, Green Thumb is a national non-profit corporation currently operating in 45 states and U.S. territories that provides training for mature and disadvantaged workers. Green Thumb's Got/IT! program delivers IT training through its training providers—Microsoft, PPI, ExecTrain, and others—to individuals who have been recently displaced or who are re-entering the work force. Several programs are offered for individuals with limited IT skills and those who are more highly experienced. Most graduates of the programs are preparing for, or have passed, certification exams to further validate and advance their training. The program provides opportunities and support to more than 40,000 people each year.
http://www.greenthumb.org

Such strategies to tap nontraditional pools of labor may meet a limited number of employers' needs and, as such, should be employer-driven, rather than seen as a broad-based, one-size fits all approach. Programs of this type need to be carried out in close partnership with employers.

Steps To Tap Non-traditional Pools Of Labor

Identify nontraditional candidates for IT jobs.

- Federal and state governments could develop an instrument for use in government employment and training programs, applied at the state and local level, to screen work force entrants, and others for interest and aptitude in IT. This assessment tool could also map a candidate's current skills and identify the training needed to perform in IT jobs. Promising candidates would be linked with training programs and employers.

Develop training programs for moving nontraditional pools of labor into IT jobs.

- The business community, and state and local governments could establish regional plans to train dislocated workers for IT jobs.
- The Federal government, in partnership with industry where appropriate, could develop a bridging program to provide short-term training to technical workers leaving the armed forces to prepare them for civilian technical jobs, including jobs in the Federal government. When departing members of the armed forces request, send data on technical skill sets to local employment and training officials to notify them of employee resources returning to the area's civilian work force.
- The Federal government could also ensure adequate IT worker training in the Native American community supported by the Department of the Interior, and focus some economic development efforts toward having businesses tap Native American workers trained in IT.
- Employers and educators could work to develop short IT training programs for graduates of non-IT college programs, tied to a work commitment and apprenticeship at the companies where trainees can gain real-world experience.

Increasing the Participation of Groups Underrepresented in the Technical Professions

Workplace diversity is increasingly recognized as an organizational asset. Many companies operate in global markets, and a diverse work force is more capable of serving a diverse customer base. Moreover, in industries and workplaces that thrive on creativity and innovation, a diverse work force produces different perspectives, different approaches to solving problem, and a richer pool of ideas.

Congresswoman Constance Morella pointed out there were more women in the clergy than in electrical engineering.

As we enter the 21st century, two-thirds of new work force entrants will be women and minorities. Yet, today, women and some minorities are underrepresented in the technical work force, including the IT work force. This outcome partly originates in the technical education pipeline.

Women and Minorities in the IT Work Force

While women represent a significant portion of the IT work force, their highest levels of representation are in administrative support positions such as data entry keyers and computer operators. In the professional level IT work force, women represent only 26.9 percent of computer systems analysts and scientists, and only 28.5 percent of computer programmers.[70] Congresswoman Constance Morella pointed out there were more women in the clergy, where they were 12 percent of the work force in 1998, than in electrical engineering where women were 9 percent of the work force. A representative from Microsoft noted that, in a survey of 360,000 Microsoft Certified Professionals, only 11 percent were female.

Some minorities are also underrepresented in the IT work force. As with women, Blacks and Hispanics have their highest levels of representation as data entry keyers and computer operators. At the professional level, Blacks represent only 7.2 percent of computer systems analysts and scientists and 6.4 percent of computer programmers. Hispanics account for only 3.6 percent of computer systems analysts and scientists, and only 4.9 percent of computer programmers. For both Blacks and Hispanics, this is significantly lower than their overall rates of work force[71] participation. In a *Network World* survey[72] of executives with hiring responsibility, one-third of 200 respondents said they had never hired a woman in their network departments; 37 percent had never hired a minority.

Women, Minorities Underrepresented in the Technical Education Pipeline

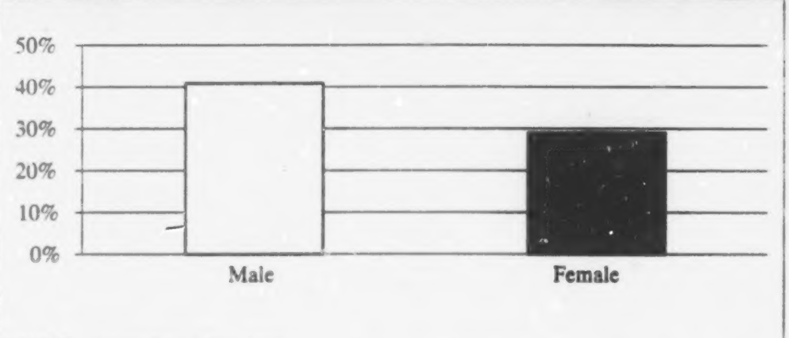
The underrepresentation of women and minorities in the professional IT work force stems partly from their underrepresentation in the technical education pipeline that leads to these jobs.

Women in the Technical Education Pipeline

Women leave high school about as well prepared in math and science as men.[73] In computers, however, according to a report by the American Association of University Women's Educational Foundation, while 30 percent of high school boys take a computer science course, 25 percent of high school girls do. Only 2 percent of high school girls take a computer applications course, compared to 6 percent of boys.[74]

While women earn more than half of all bachelor's degrees, they are less likely to earn degrees in science and engineering than men. The science and engineering selection rate—those earning degrees in science and engineering as a percentage of the total bachelor's degrees awarded in all fields—is much lower for women, 29 percent, than for men, 41 percent (see Figure 21). Women who earn bachelor's degrees earn them in engineering at a much lower rate than men (9.4 percent for men versus 1.7 percent for women) (see Figure 22), and men are three times more likely than women to choose computer science as a field of study (see Figure 23). This suggests that increasing women's participation in the education pipeline that leads to many IT jobs may require efforts to get more college-bound women to choose science and engineering as a field of study, especially computer science and engineering disciplines.

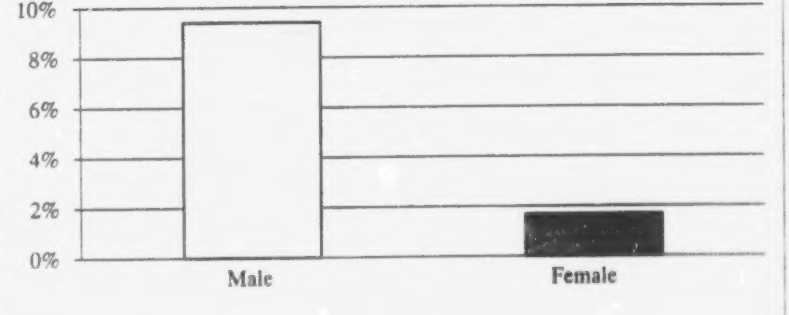
FIGURE 21. 1996 S&E Selection Rates
Bachelor's Degrees, by Sex
U.S. Citizens & Permanent Residents



SOURCE: *National Science Foundation*

There are many efforts underway to increase the awareness and interest of girls in science and technology careers. The ***Girl Scouts of the U.S.A.*** has a variety of programs to increase the interest of girls in science and technology by providing fun yet valuable hands-on learning experiences. Starting with the youngest program age level, girls can participate in projects and earn awards involving computers and technology. Older girls can interact with positive women role models who are active in science and technology careers. Some local Girl Scout councils sponsor career exploration and "Walk-A-Day in My Shoes" internships in which girls can find out what it is like to work in a professional career by spending time side-by-side with a mentor in a local company or organization. Such programs are important for helping to establish connections with professionals in

FIGURE 22. 1996 Engineering Selection Rates
Bachelor's Degrees, by Sex
U.S. Citizens & Permanent Residents



SOURCE: *National Science Foundation*

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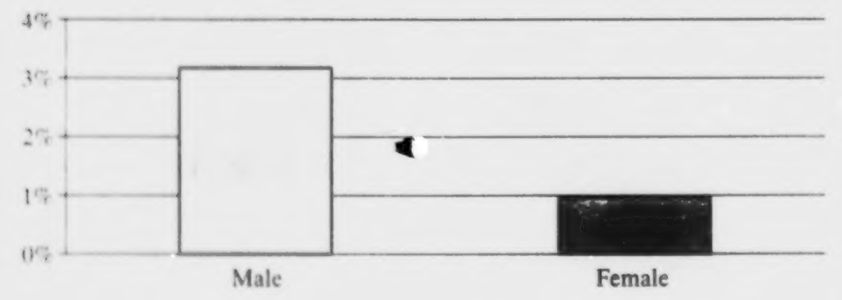
the community. Local councils often collaborate and coordinate these type programs with the outreach activities of other organizations like the American Association of University Women.
http://www.gsusa.org/

Founded in 1974, the ***Math/Science Network*** is a non-profit membership organization of educators, scientists, mathematicians, parents, community leaders, students, government, and corporate representatives with a mission to promote the continuing development in mathematics and science of all people, with particular emphasis on the needs of women and girls. To achieve this, the Network coordinates Expanding Your Horizons in Science and Mathematics (EYH) conferences for sixth through twelfth grade girls in over 130 locations across the United States each year. The goals of the locally sponsored and organized conferences are: 1) to provide young women with opportunities to interact with positive women role models who are active in math and science-related careers, 2) to increase the interest of young women in math and science by providing exciting and fun hands-on learning experiences, 3) to involve young women with limited opportunities for success in positive experiences in mathematics and science, and 4) to foster awareness of opportunities in science and math related careers. To date, more than 500,000 girls have attended EYH conferences. Samples of local survey responses indicate that more that half the girls participating in these conferences report greater appreciation and interest in careers in math and science.
http://www.elstad.com/msn.html

FIGURE 23. 1996 Computer Science Selection Rates
Bachelor's Degrees, by Sex
U.S. Citizens & Permanent Residents



SOURCE: National Science Foundation

Minorities in the Technical Education Pipeline

Some of the underlying factors contributing to the underrepresentation of Black, Hispanic, and Native American students in the technical education pipeline are different than those for women.

In 1996, large differences remained at all grade levels in the math and science achievement scores of Black and Hispanic students compared with Whites and Asians. Native American students generally scored closer to the national average than did Black or Hispanic students.[75]

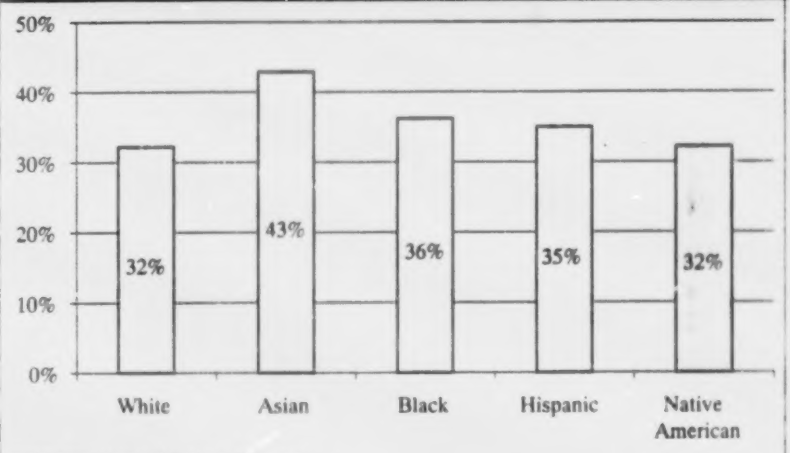
There are disparities in the types of math and science courses taken. Forty-four percent of Black, 46 percent of Hispanic, and 41 percent of Native American high school graduates have taken chemistry (compared to 58 percent of White and 69 percent of Asian/Pacific Islander students). Less than 20 percent of Hispanic and Black high school graduates have taken physics (compared to 26 percent of White and 44 percent of Asian/Pacific Islander high school students).[76]

There are also disparities across racial and ethnic groups in advanced mathematics course taking. Fifty-eight percent of Black high school graduates have taken geometry, 69 percent of Hispanics, and 60 percent of Native Americans (compared to 72 percent of White and 75 percent of Asian/Pacific Islander students). Forty-four percent of Black high school students, 49 percent of Hispanics, and 42 percent of Native American students have taken algebra 2 (compared to 72 percent of White and 75 percent of Asian/Pacific Islander students). In calculus, about one-quarter of Asian/Pacific Islanders completed the course compared with 10 percent of White, 6 percent of Hispanic, and 4 percent of Black and Native American high school students.[77] Advanced courses in math and science typically are required for admission to college-level science and engineering programs.

Black and Hispanic students are less likely to complete high school than White students. For persons 25 years of age or older, 61.8 percent of Hispanics and 86.9 percent of Blacks have completed high school, compared to 92.9 percent of Whites.[78] In addition, White high school graduates are more likely to attend college than Black or Hispanic high school graduates.

Racial and ethnic minority college freshmen declare science and engineering as a major at a rate equal to or greater than White college students (White 32 percent, Asian 43 percent, Black 36 percent, Hispanic 35 percent, and Native Americans 32 percent, see Figure 24). Black and Hispanic college students earn bachelor's degrees in science and engineering at rates roughly equal to White students but less than Asian students (White 33 percent, Asian 49 percent, Black 32 percent, Hispanic 33 percent, and Native American 33 percent, see Figure 25). There is some difference in the rate at which different ethnic and racial minorities earn engineering degrees, as a percent of all bachelor's degrees awarded (White 4.9 percent, Asian 10.8 percent, Black 3.3 percent, Hispanic 5.3 percent, and Native American 3.6 percent, see Figure 26). Of racial and ethnic minorities who earn bachelor's degrees, Blacks and Hispanics earn them in computer science at rates equal to or greater than White or Native American students (White 1.7 percent, Asian 3.9 percent, Black 2.7 percent, Hispanic 1.8 percent, and Native American 1.3 percent, see Figure 27). This suggests that the principal way to improve the participation rates of Black, Hispanic, and Native American

FIGURE 24. Proportion of Freshmen Intending to Major in Science and Engineering, by Race/Ethnicity, 1996



SOURCE: National Science Foundation

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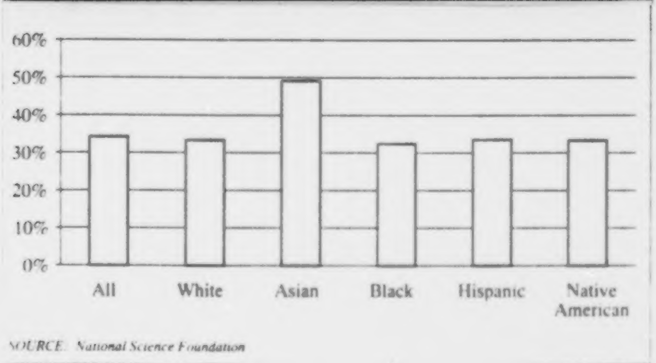
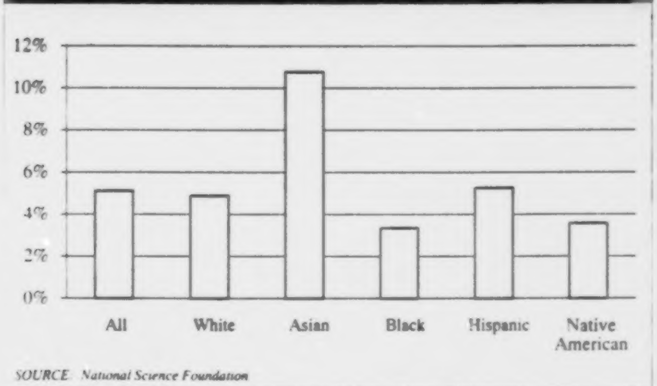
FIGURE 25. 1996 S&E Selection Rates
Bachelor's Degrees, by Race/Ethnicity
U.S. Citizens & Permanent Residents



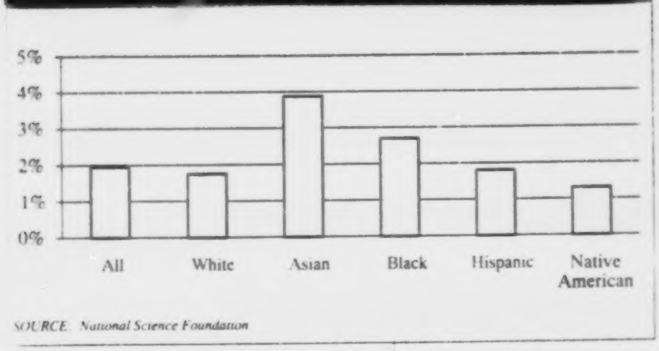
SOURCE: National Science Foundation

FIGURE 26. 1996 Engineering Selection Rates
Bachelor's Degrees, by Race/Ethnicity
U.S. Citizens & Permanent Residents



SOURCE: National Science Foundation

FIGURE 27. 1996 Computer Science Selection Rates
Bachelor's Degrees, by Race/Ethnicity
U.S. Citizens & Permanent Residents



SOURCE: National Science Foundation

minorities in science and engineering is to increase their presence in the overall pool of undergraduate students.

Between 1996 and 1997, there was a significant decrease in the number of Black and Hispanic first-year enrollments in graduate-level science and engineering programs. Among the contributing factors identified in a study by the American Association for the Advancement of Science were students' choosing to move into a strong job market, and a changing climate affecting minority education resulting from the *Hopwood v. State of Texas* court decision and the ruling of the Regents of the University of California.

There are many efforts underway to improve math and science proficiency among minority groups at the middle and high school level. The ***Algebra Project*** is an interactive pre-algebra program to help inner city and rural middle-school students better understand mathematical concepts. The program, funded through private and public donations, began in 1982 when Bob Moses, a mathematician and civil rights leader, won a "genius grant" from the MacArthur Foundation to establish a program to deliver his innovative curriculum. Incorporated in 1991, the project is designed to help disadvantaged children develop positive attitudes and problem solving skills by supplementing their regular sixth and seventh grade math classes. The curriculum involves students in a five-step process in which they use their physical surroundings as tangible references for mathematical ideas. The Algebra Project currently operates 22 project sites in 13 states.
http://www.algebra.org

The ***Promotion and Awareness of Careers in Engineering and Science Program (PACES)***, established in 1975, is a mentoring program sponsored by the Society of Mexican American Engineers and Scientists (MAES). The goals of the program are to: provide role models and mentors, instill an interest in engineering and science in junior high and high school students, remind secondary students of the privileges of a higher education, and increase the number of Mexican American and Hispanic youth preparing for engineering and science related fields. Approximately 450-500 students are participating. The program is implemented nationwide by student chapters of MAES at nine colleges and universities. At the junior high school level, the PACES program promotes college education as a realistic and achievable goal, tries to interest parents in engineering and science careers for their children, and instills a feeling of

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excitement about education. At the high school level, the MAES mentors work directly with students to: advise them of the requirements and expectations of college life as an engineering or science student; discuss university services, including financial aid; explore university options; provide tutoring; and arrange for field trips to universities and other centers of relevant science and technology.
http://www.tamu.edu/maes/paces

The ***National Black Data Processing Associates' High School Computer Competition:*** The High School Computer Competition is a mentoring program for minority high school students sponsored by local chapters of the National Black Data Processing Associates. There are more than 1,660 active student members. The goal of the program is to provide students with information about computer history, terminology, theory and programming and to provide hands-on experience in Visual Basic design, coding, documentation and testing. The program is targeted to students in the ninth through eleventh grades. Mentoring and educational assistance is provided to students at computer training camps during the winter and spring months of the school academic year. Five students from each of the chapter-sponsored training camps are then selected to compete in a national competition for scholarships at the association's national annual conference.
http://www.bdpa.org

Other programs focus on developing math and science skills in the early years and encouraging transition to college technical programs or the workplace. Through a partnership between Intel and the Gila River Indian community, six technology education centers on the reservation are being used to improve the math and science education of Native Americans from kindergarten through college. These technology centers are complemented by a college prep program, school-to-work internships, and school-community alliances that keep students focused on math and science.

The ***National Action Council for Minorities in Engineering (NACME), Inc.*** is a 25-year old not-for-profit corporation, supported by 200 of America's leading companies and universities, whose mission is to increase the representation of successful African Americans, Latinos, and American Indians in the Nation's engineering work force. NACME develops and operates pre-college and university programs and disseminates information nationally through broadcasts, conferences, publications and the Internet. NACME is the Nation's largest private source of scholarships for minority engineering students. Scholarships programs provide comprehensive student support, including intense academic preparation, financial aid, mentoring, professional development and internships. Ten percent of all minority engineers graduating since 1980—more than 7,000 engineers and computer scientists—went through college with NACME scholarships. Other NACME efforts focus on: increasing the number of high school graduates prepared to pursue an engineering degree, increasing the number of minority freshmen who go on to graduate and who achieve academic excellence, and bridging the gap between academic skills and those needed to succeed in the workplace. The *Engineering Vanguard Program* provides intense academic training and leadership development to culturally diverse teams of promising high school students from economically disadvantaged communities. The

Corporate Scholars Program identifies high-potential engineering students and pairs them with leading technology intensive companies to promote outstanding achievement and targeted work force development. NACME was one of six institutions in 1996 to share the first Presidential Award for Excellence In Science, Mathematics and Engineering Mentoring, and was recently named a recipient of the U.S. Department of Labor's 1998 EPIC (Exemplary Public Interest Contribution) Award. http://www.nacme.org

Mathematics, Engineering, Science Achievement (MESA) USA is a national organization with eight participating states: Arizona, California, Colorado, Maryland, New Mexico, Oregon, Utah, and Washington. The program aims to produce trained technological professionals to enter the work force and assume leading positions in industry. Established in 1970 at the University of California-Berkeley, the program serves educationally disadvantaged students and, to the extent possible by law, emphasizes participation by students from groups with low eligibility rates for four-year colleges. State governments, corporate contributions and various grants fund MESA. MESA provides a rigorous learning environment that includes individual academic planning, MESA classes, study skills training, peer group learning, career exploration, parent involvement, and other services for students from elementary through college level. MESA has been profiled in *Science* magazine as one of the top programs in the Nation that is successfully producing minority science professionals. In California in 1996-97, 90 percent of MESA high school graduates went on to a college or university. MESA's Engineering Program students comprised 90 percent of all the state's underrepresented graduates who attained bachelor's degrees in engineering and 84 percent of MESA's community college students transferred to four-year institutions as math, engineering, computer science or science majors. In 1996-97, MESA served over 20,300 students at pre-college, community college, and university levels.

The ***TechWorks Project*** at the New Orleans Center for Science and Mathematics is a high school level industry-based certification program preparing students for IT careers. More than 300 students attend this special school for hands-on learning for half the day, then return to their home high schools for the other half. The school is 65 percent female and 93 percent African-American. Seventy percent of the students are at the poverty line or below. Through a four-year series of internships and innovative classroom instruction within this citywide magnet Science and Math High School, TechWorks trains underrepresented, inner-city youngsters for Microsoft Certified Professional certification and other work skills. Students refurbish and fix donated computer hardware, assist in setting up and maintaining computers in other public schools, and provide advice and instruction to teachers and students in those schools. After earning the first certification in their junior year, seniors spend one full year as hands-on intern network administrators on full-size networks and earn additional certification. Graduates are guaranteed employment, loaned a home computer, and mentored by their teachers for a "13th year" to ensure successful transition into the workplace. Some students even went on to successfully start their own IT business and came back to the school to share that process with younger students.

Factors Contributing to Underrepresentation of Women and Minorities in the Technical Fields

Encouragement: Women and minorities may experience less encouragement to enter technical education and careers, and have few role models and mentors in science and engineering in school, at home, at work, among high-tech business owners and executives, or in the community. At the Gulf States meeting, a representative of the educational community pointed out that "Smart little girls are not the girls that are popular. It's very difficult to promote science and math when these are not the little girls that get all the praise." In another example, teachers often serve as role models and mentors, yet only 6.1 percent of full time instructional faculty in college engineering programs are women, and only 5.9 percent are Black or Hispanic. Women are better represented in full time computer science faculty, at 20 percent, but Blacks and Hispanics make up only 5.2 percent of full-time instructional faculty in computer science.[79] Encouragement may be lacking in the home; based on the family's work history and parental aspirations for children, technical careers may not be considered an option and children are steered into other fields. Lack of encouragement, role models, and mentors can translate into limited exposure to science and technology information and careers, as well as fewer opportunities for educational and career positioning. For example, in a recent Harris Poll conducted for the American Association of Engineering Societies, 78 percent of women felt that they are not very well or not at all informed about engineering and engineers.

Lack of encouragement, role models, and mentors can translate into limited exposure to science and technology information and careers.

Access: Some racial and ethnic minorities suffer a disproportionate impact from poor schools at the K-12 level, for example in the inner cities. For minority students, lack of financial resources can constitute the greatest barrier to achieving a technical degree. Technical education is an intense field of study that often does not allow students to hold full-time jobs. For minority students, who are disproportionately poor and often operating at the edge of financial viability, an economic setback can mean a student must withdraw from the university. In higher education, there may be a lack of linkages—in R&D, internship opportunities, and recruitment—between high-tech industries and historically Black colleges and universities, Hispanic colleges and universities, and Native American schools. This reduces opportunities for technical training, real-world experience, exposure to high-tech industries, and for spring boarding into jobs through the industry-academic partnership pipeline. Lack of recruitment reduces the "market pull" on those students choosing the focus of their education. Also, many IT companies operate in suburbs where the job pool is mostly White, and away from cities where many minority workers live.

At the Maryland meeting, a representative of the high tech community noted that the Washington, D.C. metropolitan area has large Hispanic, African American, and Asian communities. "We should create alliances through every level—high schools, associations, sororities, NAACP, ACSO program, at the junior high school level—and support them wholeheartedly for these particular needs." Such alliances would help create a pipeline of opportunity for all interested parties. For example, Microsoft has provided $16.7 million in software, technical support, faculty training and internship opportunities for students at the 41 colleges of the United Negro College

Fund (UNCF). The company is also working closely with seven UNCF schools to support and help further develop their computer science curricula.

Exposure to Technology: In groups with few economic means, there may be an absence of computer literacy in the population, and inadequate resources to invest in computer-related education or equipment both at home or in schools. White households are more than twice as likely to own a computer as Black or Hispanic households, and nearly three times as likely to have on-line access.[80] The ***Technology Access Partnership Foundation*** (TAP) was established to promote and provide access to IT for underrepresented groups within the San Bernardino, California area. Key objectives include improving public access to computer workstations, providing funding for computer labs and training programs, establishing scholarships for technology students, and providing technology access to underrepresented small businesses. TAP's Technology Mentor Program is designed for economically disadvantaged youth between the ages of 16 and 21 who are interested in obtaining classroom instruction and field experience in IT as it relates to the business environment. As part of their community internship, students act as "Technology Mentors" for local community members interested in obtaining employment, health, education, legal, and related information from the Internet. The program is located at two community sites and has trained a dozen students in Microsoft Office applications, web page design, and using the Internet to conduct research.
http://www.tapf.org

***Support Networks*:** Women have fewer and less developed networks than men in both school and the business community, as well as fewer relationships with influential colleagues, mentors, and sponsors. Mentors and sponsors can contribute to career success, by helping people "learn the ropes," explaining the unwritten rules, and sharing knowledge about the organization or the industry.[81] Minorities in science and engineering, and in the high-tech workplace also have fewer networks, and fewer relationships with mentors, role models, and sponsors. In a *Network World* reader survey, 70 percent of the respondents said their companies had policies to encourage the hiring of women and minorities. However, 80 percent of the respondents said their companies did not have initiatives to nurture the careers of women and minorities through mentoring or leadership training.[82]

Founded in 1995, ***Webgrrls*** is a professional organization that provides a forum for women employed in, or interested in new media and technology to network, teach and mentor, and learn the skills necessary to succeed in the technical workplace. Twenty-five local chapters in the United States sponsor outreach programs to young women between the ages of 15-18 to teach them about the Internet and emerging technologies and to expose them to positive images of other women in technical careers. Local chapters often participate in the outreach efforts of other organizations, such as those sponsored by Girl Scout troops and high schools, to teach young women about safe use of the Internet, and careers and opportunities in computer and emerging technologies.
http://www.webgrrls.com/

The Potential for Bringing More Disabled Americans Into the Technical Work Force

While persons with some kind of disability make up 20 percent of the U.S. population, they comprise only 5.8 percent of the science and engineering labor force.

The U.S. Department of Education's Assistant Secretary for Special Education and Rehabilitation Services stressed that for too many years, disabled people have not been considered a population of individuals who could work. In fact, the vast majority of disabled individuals are interested in working. Advances in technology have opened up employment opportunities to people with disabilities, yet many employers embrace stereotypes and fears about people with disabilities, and perceive that accommodations are too expensive, even though average accommodations are not.

Telecommuting can offer new opportunities for employment for people with disabilities. It allows the employee to work from home, in an environment that typically has been converted into an accommodating space. Yet, many employers are still uncomfortable about employees working at home—disabled or not. Many managers believe that employees who work off-site may not work required hours, or even as hard as those who are under supervision in a traditional workplace.

The Assistant Secretary also said that disabled students are still not taking the types of science and math courses that they should be taking. She encouraged employers involved in school-to-work programs to identify students with disabilities and ensure that they are part of the program.

Established in 1983, the ***High School/High Tech*** national mentoring program is sponsored by a partnership between the President's Committee on Employment of People with Disabilities, the American Association for the Advancement of Science, Mitsubishi Electric America Foundation, and the National Alliance of Business. There are currently 18 programs with approximately 850 students located in 12 states, including Florida, Maryland, California, West Virginia, Virginia, Pennsylvania, Georgia, Oregon, Iowa, Alabama, New Jersey, and Ohio. The goal of the program is to encourage high school students with disabilities to pursue post-secondary education leading to professions in science, math, engineering and technology-related fields. The program is funded through grants from NASA, Bechtel Corporation, the Federal Transit Administration, the National Weather Service, the National Marine Fisheries Service, the U.S. Department of Agriculture, Lockheed-Martin, and local sponsors. Mentoring activities include field trips, training experiences, workshops, paid internships, site visits and informational resources. The paid internships and site visits have been the most encouraging components of the program, and have included Federal agencies and private companies like NASA, the U.S. Department of Agriculture and Lockheed-Martin Corporation. To date, 7,000 students have completed the High School/High Tech program, of which 40 percent have been minorities and women.
http://www.pcepd.gov/projects/high.htm

While persons with some kind of disability make up 20 percent of the U.S. population, they comprise only 5.8 percent of the science and engineering labor force.

Steps To Increase The Participation Of Underrepresented Groups

Increase linkages with groups representing women and minorities.

- Government and industry should engage in a dialogue with national organizations representing minorities, women, and the disabled, and engage their support in a range of efforts to increase the participation of underrepresented groups in technical education and careers.

Encourage women and minorities to seek technical education and succeed in technical careers.

- Businesses could offer post-secondary scholarships in science and technology through groups representing women, minorities, and the disabled.
- Government and industry could develop fact-based stories, posters, and a web site aimed at middle and high school students which depict women and minorities in science and technology.
- Businesses, industry associations, and Federal science and technology agencies should create alliances with women's and minority schools and colleges, sororities, other students groups, Native American tribes and schools, and professional associations. Through these alliances, they could then expand technical worker recruitment efforts, recruit for internships, and offer mentoring and training opportunities.
- Educators should help expand the number of role models by aggressively recruiting women and minority faculty for science and technology programs at the middle school, high school, and college level.

Develop networks of support and encouragement for women and minorities pursuing science and technology education and careers.

- Employers should sponsor opportunities for women and minority technical employees to network and share information, experiences, and concerns through work site support groups and networks, employee councils, or other measures.

IX. ANSWERING THE INFORMATION TECHNOLOGY WORK FORCE CHALLENGE: THE FEDERAL GOVERNMENT

Administration Initiatives

Department of Commerce

GO4IT Web Site: In July 1998, the Office of Technology Policy launched a web site on the IT work force. Through the web site, which lists more than 200 resources, visitors can learn about high-tech work force initiatives across the country, tap valuable information resources, and network with other people who can offer insight and opportunities for collaboration. For example, companies can explore ways that other companies have used to develop a skilled work force. Individuals can get information on scholarships, internships, training, and job banks. State and local government agencies can find out what other governments are doing to build a high-tech work force.
http://www.go4it.gov

Department of Education

During the IT Work Force Convocation held in January 1998, the Education Department announced $6 million in grants to expand employer involvement in school-to-work programs. Among the awards since made has been a grant to a school-to-work project cooperatively sponsored by the National Alliance of Business, the Information Technology Association of America, and the Education Development Center, Inc. The goal of the project, the Techforce Initiative, is to highlight and expand IT employer involvement in School-to-Work or School-to-Careers activities nationwide by facilitating and supporting the efforts of individuals and organizations committed to building IT-focused School-to-Careers partnerships. Major activities of the project include managing a Learning Network of Centers of Excellence for IT and School-to-Careers, organizing regional symposia for IT industry leaders and educators around the country, developing champions for IT School-to-Careers within the industry and educational communities, and widely marketing the great role and potential of IT School–to–Careers in addressing the IT workers/skills issue.

Department of Labor

In Spring 1998, two Department of Labor supported information systems, America's Talent Bank and America's Job Bank, were integrated to create an $8 million nationwide network linking employers and job seekers into one Internet-based system. America's Job Bank's computerized network can now link state Employment Service offices to provide job seekers with the largest pool of active job opportunities available anywhere and nationwide exposure for their resumes. For employers it provides rapid, national exposure for job openings and an easily accessible pool of candidates. In addition to the Internet, the job openings and resumes found in America's Job Bank are available on computer systems in public libraries, colleges and universities, high schools, shopping malls, transition offices on military bases worldwide and other places of public access. With the debut of Version 4.0 of America's Job Bank in April 1999, approximately eight to nine million individual job searches per month are being reported.

In July 1998, the Labor Department awarded $7.7 million in grants for demonstration projects, in partnerships with employers and training providers, to train dislocated workers for technology–related occupations and industries. Awards were made to eleven organizations throughout the country, which will use the awards to retrain and prepare workers for careers requiring information technology and other advanced technology skills.

Under the terms of the *American Competitiveness and Workforce Improvement Act of 1998*, the Department of Labor has been authorized to support new innovative skill demonstration programs to solve labor shortages. Approximately half the revenues generated by the $500 fee that U.S employers pay for each visa application under the H-1B nonimmigrant skilled worker program will be used to make awards to private industry councils, including regional skills alliances, to demonstrate cooperative industry/community-based approaches to work force skills development.

National Science Foundation (NSF)

The National Science Foundation received approval in March 1999 to establish a $21 million dollar education fund to provide approximately 8,000 one-year scholarships of up to $2,500 each to low–income students who pursue degrees in computer science, engineering or mathematics at the associate, undergraduate, or graduate level. These Computer Science, Engineering, and Mathematics Scholarships (CSEMS) are authorized by the *American Competitiveness and Workforce Improvement Act of 1998*. Under the terms of the *Act*, the scholarships are funded through revenues generated by the $500 fee that U.S. employers pay for each visa application under the H-1B nonimmigrant skilled worker program.

NSF has also revised its criteria for evaluating proposals for competitive research and development to emphasize greater consideration of how well a proposed activity advances discovery and understanding, while promoting teaching and learning. In addition, NSF will also evaluate projects from the perspective of how they broaden the participation of underrepresented groups, enhance the infrastructure of education and research, and provide other benefits to society.

In addition to the inherent benefit of the research project, proposals are expected to address how the proposed activity will add to the researcher(s) skills and knowledge.

Legislative Initiatives

Technology Education Capital Investment Act of 1999 (H.R. 709) — Expands National Science Foundation's (NSF) informal programs that promote the understanding of math and science to students at the pre-kindergarten through secondary education levels. The bill would also authorize the Department of Education to make matching grants to States to provide supplementary scholarships to students for study leading to a postsecondary degree in science, mathematics, engineering, or a related field. The bill would also authorize the Commerce Department to make start-up grants to institutions of higher learning to develop industry-sponsored internship programs that provide opportunities for undergraduate engineering students to receive hands-on training at local businesses. In addition, a Technology Workforce Commission would be established to report to the President and the Congress on all matters relating to the shortage of technology workers in the United States. Status of bill is pending.

Amendment of the Job Training Partnership Act (H.R.201) — A bill to amend the *Job Training Partnership Act* to establish regional private industry councils for labor market areas that are located in more than one State. The bill would authorize the Department of Labor, in cases where a labor market is located in more than one State, to establish regional private industry councils if requested by the Governors of those states. The regional private industry councils established would be in addition to the private industry councils for each service delivery area. Status of bill is pending.

Amendment of the Job Training Partnership Act (H.R.203) — Amends the *Job Training Partnership Act* to allow the use of a specified portion of direct training services funds to pay incentive bonuses to certain job training providers that place large percentages of individuals in occupations for which a high demand exists. Status of bill is pending.

Mathematics and Science Proficiency Partnership Act of 1999 (H.R. 1265) – A bill to develop a demonstration project through the National Science Foundation to encourage interest in the fields of mathematics, science, and information technology. The bill would authorize the NSF to make grants to eligible local educational agencies in urban and rural areas to develop information technology programs that build or expand mathematics, science, and information technology curricula. Eligibility requirements for educational agencies would include evidence of agreements with the private sector providing internship, mentoring, and scholarship opportunities for students who participate in the information technology program. Eligible educational agencies that receive a grant would use the funding to train teachers specifically in information technology, mathematics, and science, and to provide students with similar specialized training in those areas. Status of bill is pending.

Amendment of the Internal Revenue Code of 1986 (S.456 & H.R. 838) — The Senate Bill and its companion bill in the House of Representatives propose to amend the *Internal Revenue Code of 1986* to allow employers a credit against income tax for information technology training expenses paid or incurred by the employer. The bill would extend an estimated $112 million in tax credits over 10 years to employers who train or retrain workers in the information technology field. Employers would be eligible for tax credits for information technology education expenses of up to 20 percent per year, with a ceiling of $6,000 per employee. Businesses that focus on training or retraining individuals in designated enterprise or empowerment zones, or from designated Federal disaster regions would be entitled to a 25 percent credit, as would employers with less than 200 employees. The bill also authorizes the use of private sector providers for short term IT training, with the intent of expanding training opportunities for individuals beyond those offered by Hope Scholarships and Lifetime Learning Credits which apply only to accredited or undergraduate level training. Status of bill is pending.

Amendment of the Internal Revenue Code of 1986 (S. 211 & H.R. 323) The Senate Bill and its companion bill in the House of Representatives propose to amend the *Internal Revenue Code of 1986* to permanently extend the exclusion (Section 127) for employer-provided educational assistance and to restore the exclusion for graduate level educational assistance. Section 127 of the *Internal Revenue Code* is the tax provision that allows an employer to provide $5,250 per year in tax-free non-job related educational assistance to its employees. The current law covers undergraduate classes only and will expire on May 31, 2000. Status of bill is pending.

Regional Skills Training Alliances Act of 1999 (H.R. 733) — Authorizes the Commerce Department, in consultation with the Department of Labor, to provide grants to industry-led consortia and training alliances to assist such entities to improve the job skills common and necessary for employment in specific industries. Each consortium would consist of representatives from local businesses, state and local government, education, and employee organizations. A majority of the representatives comprising the consortium would come from industry and represent one or more industry sectors in a given region. The Alliances would provide a collaborative framework for organizations in regions to develop common skill standards, curricula, apprenticeship and job retraining programs, and to share resources to train workers. The bill would limit Federal government support to the Alliances to three years, after which the efforts would be required to be self-supporting. Status of bill is pending.

The Federal Response to Its Own IT Work Force Challenge

The Federal government is not only engaged in addressing the national IT work force challenge, but its own IT work force challenge as well. Viewed as a single employer (Federal IT workers, generally, work under the same set of human resources policies), the Federal government is among the largest, if not the largest, employers of core IT workers. In 1996, the Federal government employed 67,857 core IT workers; by 2006, BLS projects the number to climb to 96,704. In addition, it is estimated that almost half the Federal IT work force may retire or otherwise leave the Federal service during this period.

Facing an expanding IT work force and the need to replace large numbers of its current work force, the Federal government faces a daunting challenge in meeting its own IT work force needs.

In 1998 the Federal Chief Information Officer's Council (CIO Council) established a multi-agency working group under its Education and Training Committee to help address this challenge by identifying ways to recruit, retain, and re-skill IT professionals, both technicians and managers.

The Federal government's role as one of the largest employers of IT workers in the Nation means that its IT worker recruitment, retention, and re-skilling strategies can play a significant role in shaping the policies of other employers and, thus, indirectly contribute to meeting the national IT work force challenge. Office of Technology Policy staff served as chair of the working group's "The National Challenge" committee, providing data, analytical support, and contributions to the development of the group's recommendations.

The working group produced 13 primary recommendations for the CIO Council, "providing a blueprint for creating a Federal IT work force that brings innovation and creativity to all Federal functions and improves the government's service and responsiveness to its citizens."

1. ***OPM, in conjunction with the CIO Council, should continue the study of IT occupational structure and pay flexibilities.*** The Federal government faces tremendous challenges in employing and paying its civilian IT work force. Chief among them are disparate pay levels and an inflexible and outdated occupational structure. These issues must be addressed jointly with OPM.
2. ***OPM should extend beyond Year 2000 a delegated waiver authority to agencies to allow for recruitment and retention of IT professionals.*** The current retiring work force–both military and civilian–is a key potential source for IT skills and Federal program experience. Tapping this workforce requires OPM to extend its IT waiver authority.
3. ***The CIO Council should support OPM's efforts to encourage the use of existing hiring flexibilities and the establishment of a critical needs hiring authority.*** Recruiting has emerged as one of the most pressing IT challenges. Use of hiring flexibilities and a direct hire authority are needed to compete with the private sector.
4. ***A government-wide indefinite delivery/indefinite quantity (IDIQ) contract should be established for online recruiting and marketing support.*** The Federal government must take advantage of web advertising to compete for employees with the private sector; this can be accomplished most efficiently and effectively through establishment of a government-wide indefinite delivery, indefinite quantity (IDIQ) contract for online recruiting and marketing support.
5. ***The CIO Council, in conjunction with other Federal agencies, should take the lead to increase collaboration among Federal agencies to upgrade IT skills of the current work force.*** This can be

accomplished through development of skills road maps, establishment of a training and education data base, identification of best practices, and elimination of restrictions on paying for degrees/certification.

6. ***OPM should encourage Federal agencies to recruit from non-traditional labor pools.*** These include unemployed and underemployed mid-career technical professionals; military technical professionals; women, minorities, and persons with disabilities; as well as part-time workers.

7. ***Sample statement of work (SOW) language should be created for skills transfer from contractor to government.*** Skills transfers from private contractors to government employees can greatly improve the quality of the Federal work force. This obligation should be formalized in statements of work for Federal IT contracts.

8. ***The Department of Commerce, the CIO Council, and OPM should jointly conduct an information and outreach campaign to encourage students to pursue IT careers.*** The Federal government should act now to interest more students in computer professions early in their educational careers.

9. ***The CIO Council, in partnership with key Federal agencies and the private sector, should develop an IT career academy and curriculum for adoption by high schools nationwide.*** Career academies are an important source of talent for several professions and should also be established for information technology.

10. ***A scholarship and internship program should be established for promising IT students in exchange for government service.*** The Federal government will need a substantial number of IT workers in the coming years; scholarship and intern programs should be utilized to help overcome the projected shortage.

11. ***The CIO Council should encourage Federal agencies to participate in regional, sectoral, and occupational skills alliances.*** Occupational skills alliances are increasingly being utilized to address IT work force needs in the private sector and should also be utilized by the Federal government.

12. ***The CIO Council should support a continuing work force planning capability at OPM.*** Accurate, specific and timely information about the Federal IT work force is essential to understand trends and to plan accordingly.

13. ***The CIO Council should continue to support the establishment of a virtual CIO University.*** A virtual CIO University is needed to provide comprehensive training for Federal and industry IT leaders.

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Appendix 1. **Employment Sectors for Core Information Technology Workers**

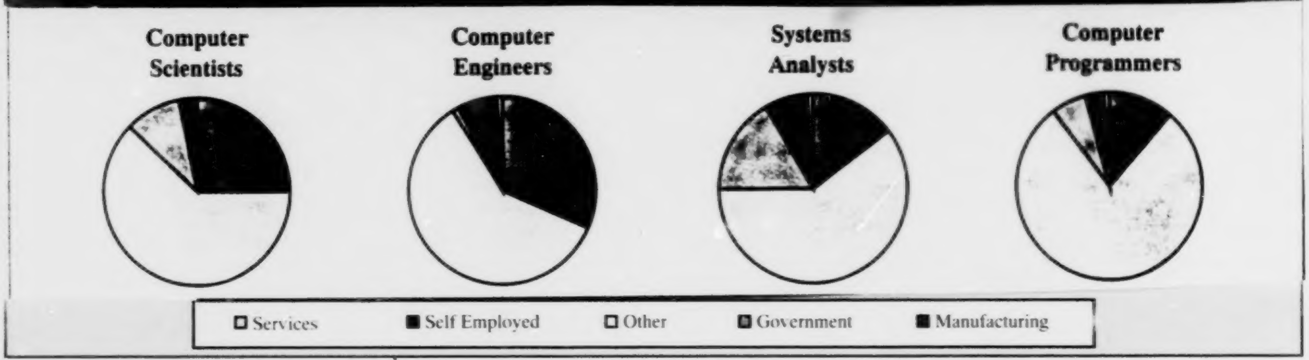
Employment Sector	**Computer Scientists†**	**Computer Analysts**	**Engineers Computer**	**Systems Programmers**
Manufacturing				
Computer & office equipment	9,776	15,364	5,916	14,027
Electronic & other electrical equipment	6,861	22,744	9,288	8,053
Instruments & related products	4,367	15,530	5,433	4,880
Chemicals & allied products including drugs	4,854	2,117	10,071	3,350
Aerospace*	2,985	3,784	10,978	5,903
Motor vehicles	1,727	656	3,451	965
All other durable goods	8,770	6,639	12,705	13,486
All other nondurable goods	13,926	1,638	17,038	14,100
Subtotal Manufacturing	**53,266**	**68,472**	**74,880**	**64,764**
Services				
Wholesale & retail trade	37,695	NA	23,133	41,047
Computer & data processing	25,285	76,451	110,662	191,866
Finance, insurance & real estate	14,617	4,279	67,602	78,300
Health	10,723	1,521	14,916	11,178
Transportation	6,784	483	6,316	8,891
Communications & broadcasting	4,422	2,778	9,063	9,685
Electric, gas & sanitary	3,668	619	8,018	4,253
Research & testing	2,967	8,378	6,795	12,180
Management & accounting	2,425	10,440	18,371	20,083
Engineering & architectural	1,196	12,452	6,755	8,693
All other services	22,253	10,657	32,805	59,102
Subtotal Services	**132,035**	**128,058**	**304,436**	**445,278**
Mining	453	409	2,886	2,419
Construction	289	1,115	687	1,535
Government				
Federal government (incl. Postal Service)	4,101	2,506	55,130	7,962
State & local government	16,174	NA	29,521	26,056
Subtotal Government	**20,275**	**2,506**	**84,651**	**34,018**
Self Employed	6,000	15,000	38,000	20,000
TOTAL	**212,318**	**215,560**	**505,540**	**568,014**

* includes BLS categories "aircraft and parts" plus "guided missiles, space vehicles, and parts"

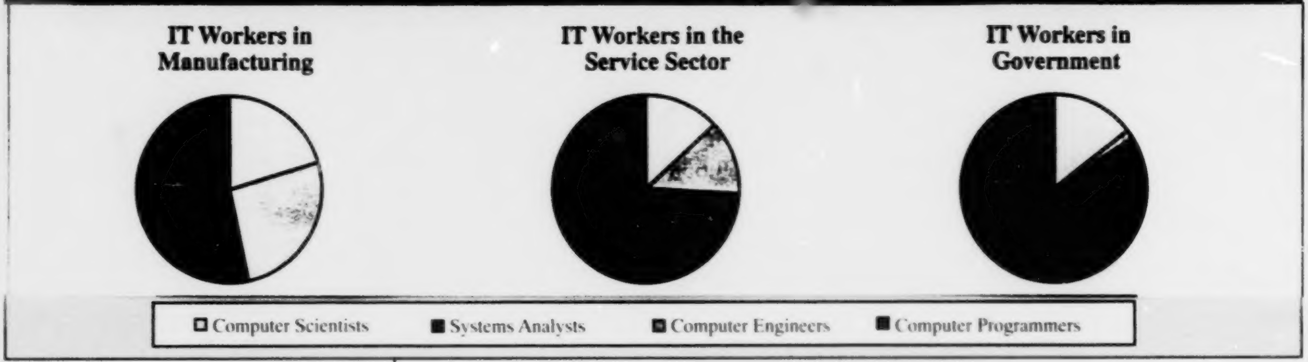
† Includes database administrators and computer support specialists

Source: Bureau of Labor Statistics, Industry/Occupation matrix, baseline data for 1996

Appendix 2. IT Work Force Distribution by Industry



Appendix 3. IT Work Force Distribution by Occupation



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Appendix 4. State Employment Projections in Core IT Occupations, 1996-2006

State	Occupation Title	Employment		Change in Employment		Average annual openings
		1996	2006	Number	Percent	
Alabama	Computer scientists	1,900	3,500	1,600	86	210
	Computer engineers	2,950	5,750	2,750	94	370
	Systems analysts	7,700	14,200	6,500	84	910
	Computer programmers	6,350	7,550	1,200	19	240
	State Totals	18,900	31,000	12,050	64	1,730
Alaska	Computer scientists	150	350	150	100	20
	Computer engineers	100	150	50	79	10
	Systems analysts	750	1,300	550	75	60
	Computer programmers	750	800	*	3	30
	State Totals	1,750	2,600	750	43	120
Arizona	Computer scientists	2,300	5,300	3,000	131	330
	Computer engineers	4,550	11,400	6,850	150	720
	Systems analysts	5,900	9,600	3,700	63	410
	Computer programmers	8,900	13,350	4,450	50	720
	State Totals	21,650	39,650	18,000	83	2,18
Arkansas	Computer scientists	650	1,300	650	97	70
	Computer engineers	350	650	300	83	30
	Systems analysts	1,800	3,500	1,700	93	180
	Computer programmers	2,700	3,050	350	13	120
	State Totals	5,500	8,500	3,000	55	400
California	Computer scientists	24,250	58,550	34,300	141	3,790
	Computer engineers	30,950	64,200	33,250	108	3,650
	Systems analysts	42,350	85,450	43,050	102	4,740
	Computer programmers	68,300	87,500	19,200	28	4,340
	State Totals	165,850	295,700	129,800	78	16,520
Colorado	Computer scientists	3,700	9,150	5,450	147	580
	Computer engineers	8,800	19,450	10,700	122	1,130
	Systems analysts	9,200	21,400	12,250	133	1,290
	Computer programmers	13,750	21,050	7,300	53	1,160
	State Totals	35,450	71,050	35,700	101	4,160
Connecticut	Computer scientists	2,300	4,000	1,700	73	200
	Computer engineers	3,300	6,400	3,100	93	340
	Systems analysts	11,600	20,450	8,900	77	1,000
	Computer programmers	10,550	10,950	400	4	340
	State Totals	27,750	41,800	14,100	51	1,880
Delaware	Computer scientists	500	750	200	41	30
	Computer engineers	200	400	200	83	20
	Systems analysts	2,650	3,850	1,200	45	140
	Computer programmers	1,400	1,550	100	8	60
	State Totals	4,750	6,550	1,700	36	250

District of Columbia Projections not available at time of publication

State	Occupation Title	Employment		Change in Employment		Average annual openings
		1996	2006	Number	Percent	
Florida	Computer scientists	7,450	15,200	7,750	104	840
	Computer engineers	9,250	16,650	7,400	80	800
	Systems analysts	20,550	39,600	19,050	93	2,050
	Computer programmers	21,350	24,000	2,700	13	930
	State Totals	58,600	95,450	36,900	63	4,620
Georgia	Computer scientists	6,000	16,200	10,250	171	1,080
	Computer engineers	4,400	11,300	6,900	156	720
	Systems analysts	13,600	34,300	20,700	152	2,160
	Computer programmers	18,750	28,950	10,200	54	1,600
	State Totals	42,750	90,750	48,050	112	5,560
Hawaii	Computer scientists	350	750	350	105	40
	Computer engineers	200	300	100	46	10
	Systems analysts	1,650	2,950	1,350	82	150
	Computer programmers	1,200	1,350	200	15	60
	State Totals	3,400	5,350	2,000	59	260
Idaho	Computer scientists	900	1,850	950	104	100
	Computer engineers	1,100	1,900	800	70	90
	Systems analysts	1,500	3,000	1,450	97	160
	Computer programmers	1,100	1,400	250	24	60
	State Totals	4,600	8,150	3,450	75	410
Illinois	Computer scientists	9,450	19,850	10,400	110	1,130
	Computer engineers	9,150	18,400	9,300	102	990
	Systems analysts	25,300	50,850	25,550	101	2,730
	Computer programmers	28,750	35,900	7,150	25	1,610
	State Totals	72,650	125,000	52,400	72	6,460
Indiana	Projections not available at time of publication					
Iowa	Projections not available at time of publication					
Kansas	Projections not available at time of publication					
Kentucky	Computer scientists	1,250	2,550	1,300	104	140
	Computer engineers	450	650	200	49	30
	Systems analysts	2,600	4,950	2,350	90	250
	Computer programmers	4,450	5,650	1,200	27	260
	State Totals	8,750	13,800	5,050	58	680
Louisiana	Computer scientists	1,950	3,650	1,700	87	180
	Computer engineers	500	800	350	68	40
	Systems analysts	4,300	7,650	3,350	79	370
	Computer programmers	3,350	4,000	600	18	170
	State Totals	10,100	16,100	6,000	59	760

State	Occupation Title	Employment		Change in Employment		Average annual openings
		1996	2006	Number	Percent	
Maine	Computer scientists	1,150	2,200	1,050	92	120
	Computer engineers	250	500	200	76	20
	Systems analysts	1,150	1,950	850	73	90
	Computer programmers	1,650	1,850	200	12	70
	State Totals	4,200	6,500	2,300	55	300
Maryland	Projections not available at time of publication					
Massachusetts	Computer scientists	7,550	16,000	8,450	112	920
	Computer engineers	12,600	24,700	12,100	96	1,300
	Systems analysts	16,450	34,300	17,800	108	1,890
	Computer programmers	17,300	21,400	4,050	24	950
	State Totals	53,900	96,400	42,400	79	5,060
Michigan	Projections not available at time of publication					
Minnesota	Computer scientists	8,000	20,950	12,900	161	1,350
	Computer engineers	4,000	9,600	5,600	141	590
	Systems analysts	10,450	20,650	10,250	98	1,090
	Computer programmers	12,100	15,050	3,000	25	670
	State Totals	34,550	66,250	31,750	92	3,700
Mississippi	Computer scientists	900	1,650	750	87	80
	Computer engineers	200	250	100	43	10
	Systems analysts	2,200	3,950	1,750	80	190
	Computer programmers	1,500	1,500	*	1	50
	State Totals	4,800	7,350	2,600	54	330
Missouri	Computer scientists	3,600	7,500	3,900	108	420
	Computer engineers	1,600	3,200	1,550	96	170
	Systems analysts	8,650	15,400	6,750	78	740
	Computer programmers	12,450	14,150	1,700	14	560
	State Totals	26,300	40,250	13,900	53	1,890
Montana	Computer scientists	400	450	*	9	10
	Computer engineers	50	100	*	35	*
	Systems analysts	500	650	150	34	20
	Computer programmers	1,100	1,300	250	21	50
	State Totals	2,050	2,500	400	20	80
Nebraska	Computer scientists	1,750	2,050	300	16	40
	Computer engineers	300	450	100	33	10
	Systems analysts	3,950	5,250	1,250	32	150
	Computer programmers	4,600	6,000	1,400	30	280
	State Totals	10,600	13,750	3,050	29	480
Nevada	Computer scientists	550	1,200	700	127	70
	Computer engineers	300	600	300	103	30
	Systems analysts	1,550	3,250	1,700	109	180
	Computer programmers	2,050	2,900	850	41	150
	State Totals	4,450	7,950	3,550	80	430

State	Occupation Title	Employment		Change in Employment		Average annual openings
		1996	2006	Number	Percent	
New Hampshire	Computer scientists	1,200	2,450	1,250	104	140
	Computer engineers	1,650	3,050	1,400	86	150
	Systems analysts	1,350	2,850	1,500	112	160
	Computer programmers	2,600	3,350	750	29	160
	State Totals	6,800	11,700	4,900	72	610
New Jersey	Computer scientists	5,300	10,800	5,500	104	600
	Computer engineers	6,400	12,300	5,900	92	600
	Systems analysts	21,900	45,900	24,000	109	2,500
	Computer programmers	30,600	36,900	6,300	20	1,600
	State Totals	64,200	105,900	41,700	65	5,300
New Mexico	Computer scientists	950	1,700	800	83	90
	Computer engineers	950	1,800	850	89	90
	Systems analysts	2,150	4,300	2,150	98	230
	Computer programmers	2,400	2,700	300	12	100
	State Totals	6,450	10,500	4,100	64	510
New York	Projections not available at time of publication					
North Carolina	Computer scientists	6,550	14,650	8,100	124	870
	Computer engineers	4,100	9,700	5,600	137	590
	Systems analysts	12,900	28,300	15,400	119	1,630
	Computer programmers	15,300	17,300	2,050	13	680
	State Totals	38,850	69,950	31,150	80	3,770
North Dakota	Computer scientists	1,150	2,050	950	82	100
	Computer engineers	*	*	N/A	*	N/A
	Systems analysts	650	1,150	500	73	50
	Computer programmers	800	950	150	16	40
	State Totals	2,600	4,150	1,600	62	190
Ohio	Computer scientists	8,500	17,450	8,950	105	970
	Computer engineers	5,550	11,250	5,700	103	610
	Systems analysts	22,200	42,950	20,750	94	2,230
	Computer programmers	19,050	22,300	3,250	17	920
	State Totals	55,300	93,950	38,650	70	4,730
Oklahoma	Computer scientists	1,900	3,400	1,500	78	170
	Computer engineers	1,000	2,150	1,150	112	120
	Systems analysts	4,250	7,550	3,300	78	360
	Computer programmers	4,900	5,500	650	13	220
	State Totals	12,050	18,600	6,600	55	870
Oregon	Computer scientists	5,750	11,000	5,250	91	560
	Computer engineers	5,150	8,250	3,100	60	340
	Systems analysts	5,350	7,900	2,550	48	280
	Computer programmers	4,150	4,950	800	19	120
	State Totals	20,400	32,100	11,700	218	1,300
Pennsylvania	Projections not available at time of publication					

State	Occupation Title	Employment		Change in Employment		Average annual openings
		1996	2006	Number	Percent	
Rhode Island	Computer scientists	900	1,800	850	97	90
	Computer engineers	750	1,650	900	115	90
	Systems analysts	1,850	3,700	1,850	101	200
	Computer programmers	1,800	2,100	350	19	90
	State Totals	5,300	9,250	3,950	75	470
South Carolina	Computer scientists	1,200	2,350	1,200	101	130
	Computer engineers	950	1,850	850	90	90
	Systems analysts	3,850	6,950	3,100	82	340
	Computer programmers	4,400	5,100	700	16	210
	State Totals	10,400	16,250	5,850	56	770
South Dakota	Computer scientists	1,750	3,800	2,050	118	220
	Computer engineers	100	200	100	81	10
	Systems analysts	450	800	300	68	40
	Computer programmers	1,100	1,250	150	12	50
	State Totals	3,400	6,050	2,600	76	320
Tennessee	Computer scientists	2,650	5,600	2,900	109	310
	Computer engineers	1,750	2,950	1,200	69	130
	Systems analysts	5,950	11,100	5,150	87	560
	Computer programmers	6,950	7,900	950	13	310
	State Totals	17,300	27,550	10,200	59	1,310
Texas	Computer scientists	12,700	25,800	13,150	104	1,440
	Computer engineers	22,500	39,500	17,000	75	1,850
	Systems analysts	34,150	64,400	30,300	89	3,260
	Computer programmers	34,950	37,800	2,850	8	1,370
	State Totals	104,300	167,500	63,300	61	7,920
Utah	Computer scientists	1,250	2,550	1,250	100	140
	Computer engineers	3,050	5,900	2,850	94	310
	Systems analysts	4,000	7,900	3,900	98	420
	Computer programmers	6,500	7,700	1,200	19	320
	State Totals	14,800	24,050	9,200	62	1,190
Vermont	Computer scientists	600	950	400	64	40
	Computer engineers	200	400	150	75	20
	Systems analysts	850	1,400	550	65	60
	Computer programmers	1,250	1,500	200	17	60
	State Totals	2,900	4,250	1,300	45	180
Virginia	Computer scientists	7,050	16,450	9,400	133	1,000
	Computer engineers	12,400	29,100	16,700	134	1,750
	Systems analysts	26,900	60,350	33,400	124	3,520
	Computer programmers	22,000	29,200	7,150	33	1,400
	State Totals	68,350	135,100	66,650	98	7,670

State	Occupation Title	Employment		Change in Employment		Average annual openings
		1996	2006	Number	Percent	
Washington	Computer scientists	9,250	20,500	11,200	121	1,200
	Computer engineers	10,950	22,450	11,500	105	1,230
	Systems analysts	14,050	25,300	11,250	80	1,220
	Computer programmers	11,000	11,500	450	4	390
	State Totals	45,250	79,750	34,400	76	4,040
West Virginia	Computer scientists	400	750	350	87	40
	Computer engineers	400	750	350	92	40
	Systems analysts	1,500	2,850	1,350	89	150
	Computer programmers	1,400	1,700	300	21	70
	State Totals	3,700	6,050	2,350	64	300
Wisconsin	Computer scientists	3,750	6,450	2,700	72	300
	Computer engineers	2,650	6,650	4,000	151	420
	Systems analysts	8,000	15,400	7,400	92	800
	Computer programmers	8,800	10,100	1,300	15	400
	State Totals	23,200	38,600	15,400	66	1,920
Wyoming	Computer scientists	200	300	100	49	10
	Computer engineers	*	*	N/A	*	N/A
	Systems analysts	200	300	100	56	10
	Computer programmers	450	450	*	5	20
	State Totals	850	1,050	200	24	40
United States	Computer scientists	211,600	460,800	249,200	118	26,830
	Computer engineers	215,650	450,950	235,300	109	25,000
	Systems analysts	505,500	1,025,100	519,600	103	55,400
	Computer programmers	568,000	697,250	129,250	23	30,600
	Totals	1,500,750	2,634,100	1,133,350	76	137,830

Computer Scientists category includes database administrators, computer support specialists, and all other computer scientists.

State projections are developed in the labor market information sections of each State Employment Security Agency.

Employment may not be found in all occupations in all States in sufficient numbers to warrant the development of occupational projections . Occupations for which projections are not available on this site for a State are indicated with an (NA) for "not available."

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